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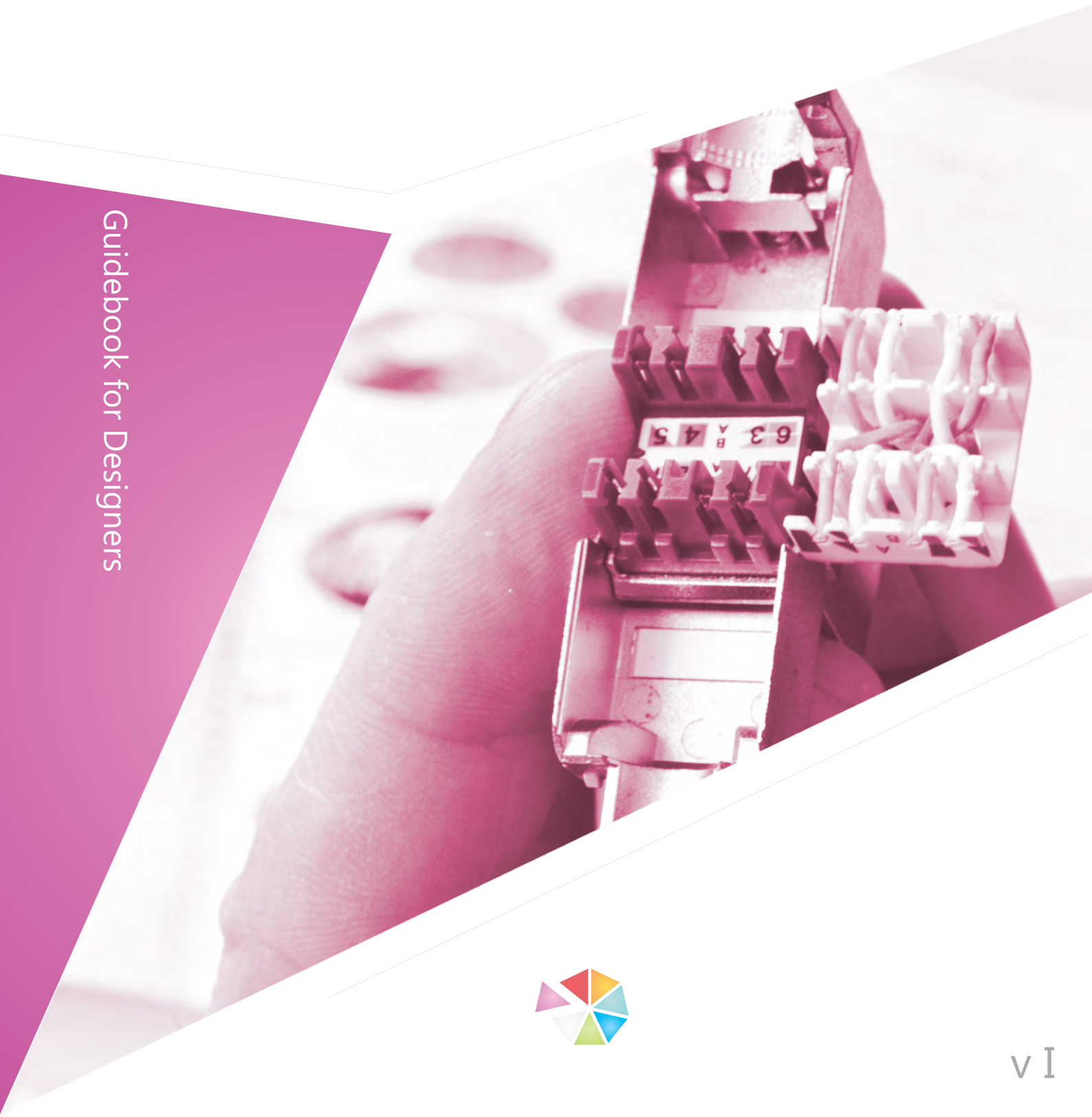

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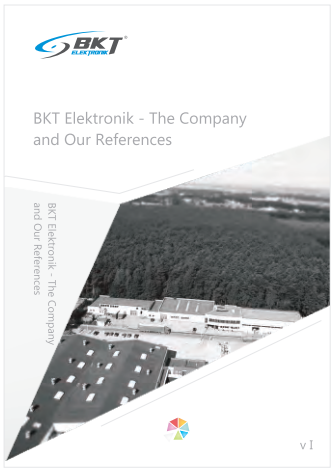
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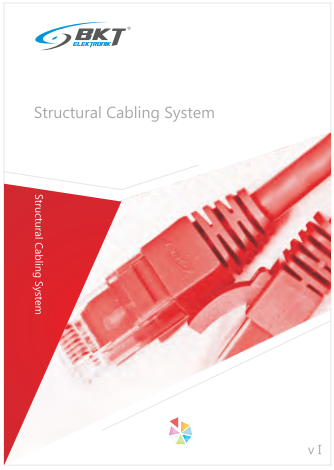
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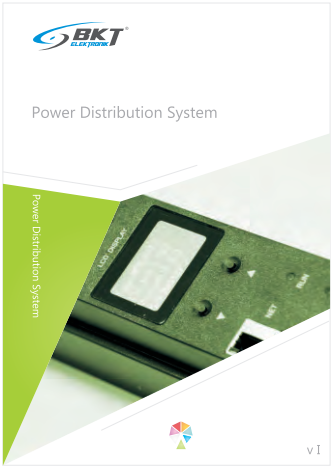
Power Distribution System
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Broadband
Broadband
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Outdoor Cabinets
Outdoor Cabinets
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Racks and Accessories
Racks and Accessories
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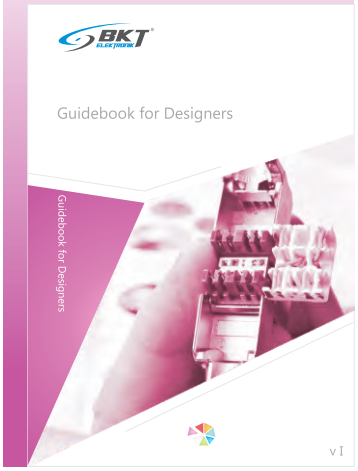
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This manual contains information necessary for correct design of Structured Cabling System (SCS) and allows the right selection of necessary elements on the basis of DRAKOM system by BKT Elektronik. Described below are copper and optical fiber paths, their assembly rules, recommended and current standards, as well as basic elements, such as: twisted-pair cables, telecommunications (multimedia) outlet, patch panels, distribution cabinets with equipment, optical fiber cables, optical fiber connectors, optical fiber patch panels, copper as well as optical fiber interconnect and crossover cables.

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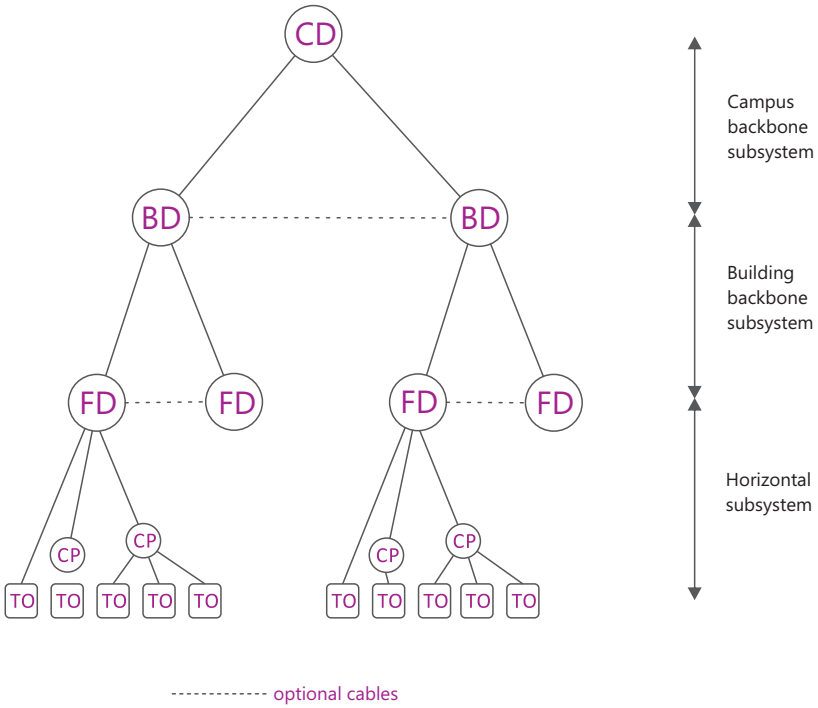
1. Standards

The manual has been created in accordance with, among others, current technical standards concerning building cabling for telecommunications products and services. The list of standards and most popular LAN standards is presented below. The standards below include all the necessary requirements and recommendations for correct design, installation and measurements of Structured Cabling System.
European CENELEC standards are marked as EN, and Polish standards as PN-EN:

PN-EN 50173-1:2013	Information Technology. Generic Cabling Systems. Part 1: General Requirements.
PN-EN 50173-2:2008 and PN-EN 50173-2:2008/A1:2011	Information Technology. Generic Cabling Systems. Part 2: Office Rooms.
PN-EN 50173-3:2008 and PN-EN 50173-3:2008/A1:2011	Information Technology. Generic Cabling Systems. Part 3: Industrial Buildings.
PN-EN 50173-4:2008 and PN-EN 50173-4:2008/A1:2011	Information Technology. Generic Cabling Systems. Part 4: Residential Buildings.
PN-EN 50173-5:2009 and PN-EN 50173-5:2009/A1:2011	Information Technology. Generic Cabling Systems. Part 5: Data Centers.
PN-EN 50174-1 .2010 and PN-EN 50174-1:2010/A1:2011	Information Technology-Cabling System Part 1: Specification of a System and Quality Assurance.
PN-EN 50174-2:2010 and PN-EN 50174-2:2010/A1:2011	Information Technology-Cabling System Part 1: Specification of a System and Quality Assurance.
PN-EN 50174-3.2009	Information Technology-Cabling System Part 3: Planning and Performing Outdoor Installation.
PN-EN 50600-1:2013-06E	Information Technology-Cabling System-Equipment and Infrastructure of Data Centers Part 1: General Concepts
PN-EN 50600-2-1:2014-06	Information Technology – Cabling System–Equipment and Infrastructure of Data Centers Part 2-1: Building Structure
PN-EN 50600-2-2:2014-06	Information Technology-Cabling Systems-Equipment and Infrastructure of Data Centers Part 2-2: Power Distribution
PN-EN 50346: 2004, PN-EN 50346:2004/A1:2009	Information Technology - Cabling System - Testing Installed Cables
PN-EN 50310 : 2011	Application of equipotential bonding and earth connections in building with installed computer equipment
Standards from PN-EN 50288	Multi-core cables applied in digital and analog data transfer technology...
ISO/IEC International Standards: ISO/IEC 11801:2002/ Amd.2:2010	Generic cabling for customer premises
ANSI/TIA/EIA US Standards: ANSI/TIA/EIA-568-C. 0-2009	Generic Telecommunications Cabling for Customer Premises
ANSI/TIA/EIA-568-C.1-2009	Commercial Building Telecommunications Cabling Standard
ANSI/TIA/EIA-568-C.2-2009	Balanced Twisted Pair Telecommunications Cabling and Components Standard
ANSI/TIA/EIA-568-C.3-2009	Optical Fiber Cabling Components Standard
ANSI/TIA-569 2011	Commercial Building Standard for Telecommunications Patchways and Spaces
ANSI/TIA/EIA-J-STD-607	Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

Structured Cabling System for office buildings (PN-EN 50173-2) contains up to three cabling systems: campus, backbone, building-backbone and horizontal, which is illustrated by the picture below



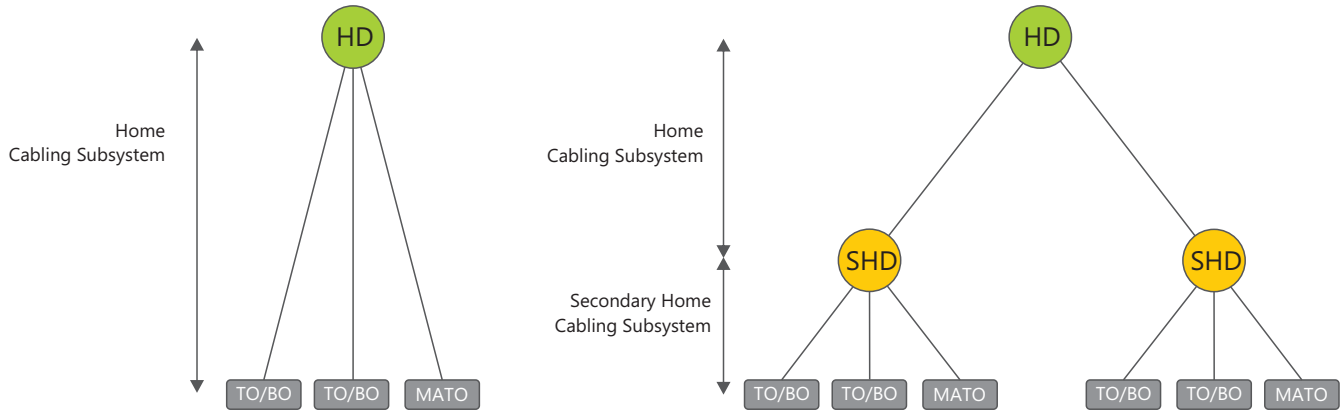
Hierarchic Structure of Structured Cabling

CD - Campus Distribution
BD - Building Distribution
FD - Floor Distribution
CP - Consolidation Point
TO - Telecommunication Outlet

Horizontal subsystem is specified in details in standards 50173 concerning particular areas of application.

Organization	Office cabling	Data Centers cabling	Industrial cabling	Home cabling
ISO	ISO/IEC 11801:2002 ISO/IEC 11801:2002/Amd 2:2010	ISO/IEC 24764	ISO/IEC 24702	ISO/IEC 15018
CENELEC	EN 50173-2: 2007/ A1:2011	EN 50173-5 2007/ A1:2010	EN 50173-3:2007/ A1:2010	EN 50173-4/A1:2010
PKN	PN-EN 50173-2:2008/A1 :2011	PN-EN 50173-5: 2009/A1:2011	PN-EN 50173-3:2008/ A1:2011	PN-EN 50173-4:2008/ A1:2011
TIA ADVANCING GLOBAL COMMUNICATIONS	ANSI/TIA-568-C.1 2012	TIA/EIA-942	TIA/EIA-1005	TIA/EIA-570-B

For houses and apartments the diagrams below apply:



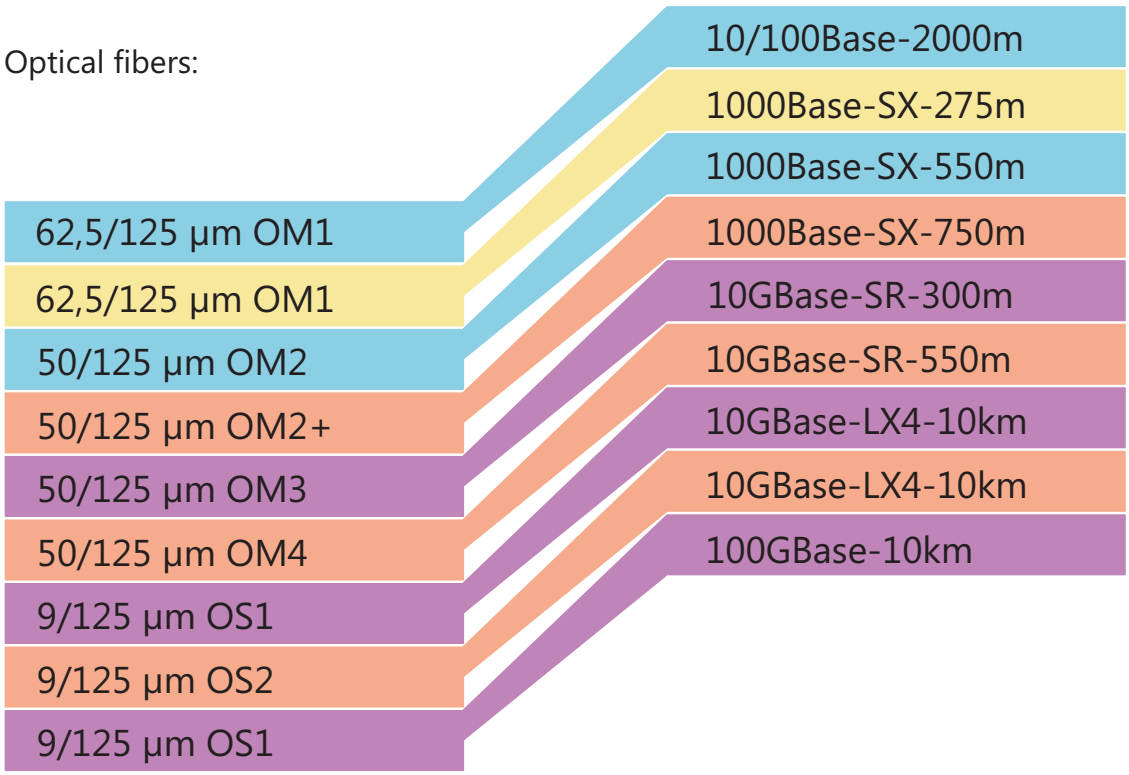
HD-Home Distribution, SHD-Secondary Home Distribution, TO-Telecommunications Outlet, BO-Broadband Outlet, MATO-Multi-application Telecommunications Outlet

Home Cabling Structure (PN-EN 50173-4)

In the case of Industrial or Data Center SCS proper standards have to be complied with.
In backbone systems for computer connections optical fiber cables are used (except for building system, where distance between distribution points is ≥ 90 m and copper twisted-pair cables might be used, although optical fiber cables are still recommended).

According to standards, maximum distances at which optical fiber cables may be used depend on the type of fibers (multi-mode OM1, OM2, OM3, OM4, single-mode OS2) and the intended signal transmission speed (100M, 1G, 10G, 40/100G).
Ranges for particular fibers and speeds are presented in PN-EN 50173-1 table F.4 and F.5.

Examples of Ranges:

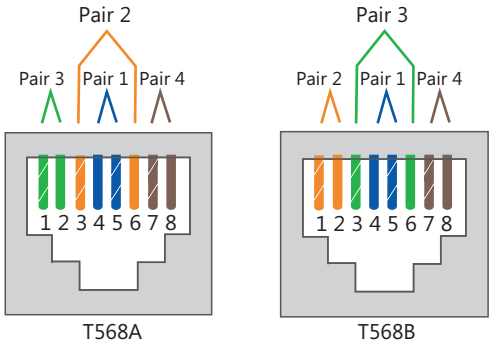


	100 MHz	250 MHz	500 MHz	600 MHz	1000 MHz
USA	TIA/EIA 568-B.1/2 Cat. 5e	TIA/EIA 568-B.2/1 Cat. 6	TIA/EIA 568-B.2-10 Cat.6A		
International	ISO/IEC11801: 2nd Edition Class D	ISO/IEC11801 2nd Edition Class E	ISO/IEC11801 2.1 Edition Class E_A	ISO/IEC11801 2nd Edition Class F	ISO/IEC11801 2.1 Edition Class F_A
Europa	CENELEC EN50173-1 Class D	CENELEC EN50173-1 Class E	CENELEC EN50173-1:2011 Class E_A	CENELEC EN 50173-1 Class F	CENELEC EN50173-1:2011 Class F_A
Deutschland	DKE DIN EN50173-1 Class D	DKE DIN EN50173-1 Class E		DKE DIN EN50173-1 Class F	

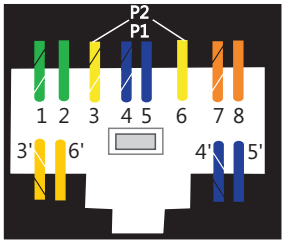
Each category is characterized by specific capacity:

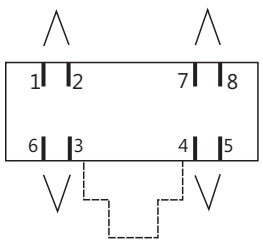
Class A	100 KHz	Cat. 1	Telephony
Class B	1 MHz	Cat. 2	128 Kbps
Class C	16 MHz	Cat. 3	10 Mbps
Class C+	20 MHz	Cat. 4	16 Mbps
Class D	100 MHz	Cat. 5	100 Mbps
Class D+	100 MHz	Cat. 5e	1000 Mbps
Class E	250 MHz	Cat. 6	1 Gbps
Class E_A	500 MHz	Cat. 6_A	10 Gbps
Class F	600 MHz	Cat. 7	10 Gbps
Class F_A	1000 MHz	Cat. 7_A	10 Gbps
Klasa I/Klasa II	1600(2000) MHz	Kat 8.1/Kat 8.2	40 Gbps (30m)

Telecommunications (multimedia) outlets for copper cabling are made for Classes from D to E_A as RJ45 and formed in two ways: according to T568A or T568B, which is illustrated by the picture below:



In order to terminate Class F and F_A cables and receive positive measurements up to 600 or 1000 MHz (Class F and F_A), GG45 sockets (downward compatible with RJ45) should be used:





Category 7
connections equipment

2. Initial Data for the Design

Before commencing the design process, as much as possible information from the Investor and future User has to be obtained. It is important that minimum requirements be specified in relation to the number of final points, efficiency and reliability of Structured Cabling System (SCS). The Investor or future User should assign a person or persons who would be able to establish what is needed or discuss suggested solutions.

The above is significant to accomplish the goal, which is the optimum SCS design that provides currently the required capacity, reliability and potential for fast and uncomplicated further development. Information technology and telecommunications develop very dynamically, which is the result of the increasing number and speed of all devices that are connected to computer network. This requires application of such solutions that will provide proper band and transmission capabilities even in 10-15 years.

That is why, devices with 10 or 100 Mbps access (except for camcorders for CCTV systems) are used less and less frequently. Today, 1 Gbps devices are starting to dominate and in the case of connections between Distribution Points, even 10 Gbps and more. In June 2010 IEEE 802.3ba 40G/100G Ethernet standard for optical fiber connections was ratified. Discussions are currently held regarding IEEE standard for 40 G-BaseT.
To make the design process easier, DRAKOM Cabling System Survey has been prepared. This document includes the most important information concerning the best parameters of a designed cabling.
Structured Cabling System can be divided into two cases:

- first: a building for SCS already exists,
- second: SCS is designed along with a building.

In the first case, we have an existing building with already usable rooms and existing infrastructure with power supply network. Before the site inspection conducted with the User, we have to obtain, if possible, the current building blueprints, on the basis of which we can initially specify the best and acceptable, from the point of view of the copper (and/or optical fiber) cabling standards, locations for Distribution Points. If the existing network is developed, its current documentation has to be obtained and verified during the site inspection. Subsequently, we establish the User's requirements concerning various types of rooms and networks, i.e. how many sockets have to be designed in particular cases (telecommunications (multimedia) outlets, e.g. a set of: 1xRJ45, 2xRJ45, 3xRJ45, ... , 2xSC OM3, 2xLC OM3 ...). During the site inspection, we verify or establish:

- the correctness of the blueprints (if we do not have any blueprints, the rooms have to be measured so that we can establish the required length of the cables and routes);
- the possibility of Distribution Points location in particular rooms or the possibility of sectioning off separate rooms from the existing ones or changing their use;
- the possibility of laying routes along with cables, making rebores and risers, potential "dangers" of electromagnetic disturbances source, pipes of water and sewerage systems, gas and industrial gas systems;
- location, mounting method and a number of telecommunications (multimedia) outlets in all rooms, as required by the User;
- power connections and earthing of cabinets for Distribution Points.

Having established the above issues, we have to verify once again if the condition of maximum distance of 90 m "by cable" between telecommunications (multimedia) outlets and Distribution Point is complied with. If the condition is not fulfilled, we have to verify and change cable routes or location of Distribution Point, or create an additional Distribution Point. We have to make sure that the condition of ⩽ 90 m for each telecommunications (multimedia) outlet is complied with.

In the second case, we design SCS along with a building. The architect gives us all the necessary information on the construction of the building. At this stage rooms for the purposes of low voltage systems, which include SCS, can be assigned. Their location has to be verified so that there is a possibility of routing the twisted-pair cable to every location, keeping in mind the ⩽ 90 m condition. It is vital that telecommunications riser ducts be separated from electrical risers and other media risers. We establish the User's requirements concerning various types of rooms and networks, i.e. how many sockets have to be designed in particular cases (telecommunications outlets, e.g. a set of: 1xRJ45, 2xRJ45, 3xRJ45, ... , 2xSC OM3, 2xLC OM3...). We coordinate the SCS with power supply network – normally at workstations 1/2/3x230V dedicated + 1/2x230V power outlets are beside 1/2/3 x RJ45 sockets. The initial room arrangements or at least specification of room's intended use would make it easier to establish the number of workstations. If we lack this information, we have to proceed according to arrangements with the Investor/User or given indicators, e.g. for office rooms 6-10 m2 per one workstation (with a specified number of telecommunications outlets). Former experience in such designs is very helpful to specify the number and arrangement of the final points. We provide at least one power circuit and proper earthing per cabinet in all Distribution Points. Main routes with a large number of cables have to be coordinated with electrical network and ventilation/air conditioning ducts.

In horizontal cabling usually twisted-pair cable is used. It is made of four properly twisted pairs. Each pair is created through physical twisting of two individually isolated copper conductors. Conductors are twisted in order to lower the emission of disturbances and increase resistance to external disturbances. Four sets of twisted pairs put together in a bundle into one sheath make up a cable.

3.1. Specifications of Twisted-pair Cables

Pursuant to PN-EN 50173-1:2011 twisted-pair cables are specified according to the following pattern:

XX/YTA where XX stands for outer shield (or screen) of cable: U-unshielded; F-foil shield; S-braid shield, SF-braid + foil shield;
Y-a shield per two pairs (four conductors); U-unshielded; F-foil shield; T-twisted; A-conductor count; P-pair (two conductors), Q-quad (four conductors).

Cables made of four twisted pairs can be divided into several different types:

U/UTP Unshielded twisted-pair cable;
F/UTP Shielded twisted-pair cable-foil shield around all pairs with a protective conductor;
SF/UTP Shielded twisted-pair cable-foil and braid shield around all pairs;
U/FTP Shielded twisted-pair cable-foil shield around each pair with a protective conductor;
F/FTP Shielded twisted-pair cable-foil shield around all pairs and each pair with a protective conductor;
S/FTP Shielded twisted-pair cable-braid shield around all pairs (copper braid, tin plated) and foil shield around each pair.

Unshielded Cable: one of the most popular in LAN networks. There are several cable performance categories and some new categories are expected to emerge. Shielded cable has a shield surrounding each pair and/or the entire cable. Additional shielding lowers disturbances.

Cable type	Category A	Category B
Unshielded	• Relatively cheaper • Prevalence in installations • Common technical solutions	• U/UTP Cat 6A cable requires special installation procedures. • Sensitive to external disturbances. • Larger diameter of U/UTP Cat 6A cable means need for larger space • U/UTP Cat 6A cables cannot be used in conjunction with other types of cables
Shielded	Better performance in comparison with unshielded cables of Cat 6A, including: • DRAKOM shielded structure is significantly thinner than unshielded ones • Lower costs of installation due to cables' smaller diameter • The cables can be used in conjunction with cables from other categories	• Bigger work load than in the case of U/UTP cables, because of requirements regarding shielding.

3.1A. Cable Specifications Regarding Fire Safety

According to currently applicable fire safety regulations, it is not required to use fire resistant or low halogen cables or cables with low content of other harmful substances that are emitted during fire.

Committees for standardization and European committees are currently working on European standards describing a range of parameters regarding cable fire safety, including telecommunications and computer cables. European Construction Products Directive (CPD) will include cables and conductors classification, as well as evaluation of smoke emissions and their corrosivity.

BKT Elektronik recommends that cables which do not emit harmful substances are used in the following places:
In buildings with higher fire risk, where human safety and cultural property protection are the priorities (hospitals, airports, schools, shopping centers, hotels) or in facilities of high value (industrial factories, power plants, data centers, banks) it is recommended that non-halogen conductors and cables (which do not emit toxic smoke when on fire) are used. Cables that do not emit harmful substances should also be used in alarm, signaling and control systems!

Cables in the following sheaths are recommended: LSOH/LSZH/LSHF/FRNC- C/LSFR-FR or with other names – common English nomenclature:

Denotation	Description
LSZH	Low smoke, zero halogen
LSF	Low smoke, fume
LSOH	Low smoke, zero(0) halogen
LSHF	Low smoke, falogen Free
LSNH	Low smoke, nonhalogen
NHFR	Nonhalogen, flame retardant
HFFR	Halogen Free, flame retardant
FRNC	Fire retardant, noncorrosive
LS	Low, limited smoke
ST	Smoke test (limited smoke)
FRLS	Fire resistand, low smoke
RE	Reduced emissions
LC	Low corrosivity
LH	Low halogen

Applicable standards:

	International IEC Standards	German Standards	PVC Sheathed Telecommunications and Computer Cables	FRNC- C/ LSFR-FR Sheathed Telecommunications and Computer Cables
Special Flame Retardant Properties of a Single Cable	IEC 60332-1	DIN VDE 0472 Part 804B	X	X
Cable Flame Spread	IEC 60332-3-24 Cat C	DIN VDE 0472 Part 804C		X
Fire Smokes Corrosivity	IEC 60754-2	DIN VDE 0472 Part 813		X
Smoke Density Measurement	IEC 61034-1	DIN VDE 0472 Part 816		X

BKT telecommunications and computer cables are available in PVC, FRNC and LSFR-FR sheathing.

3.2. IEEE Nomenclature

Electricians and Electronic Engineers Institute (IEEE) works out network standards for cabling, power supply topology, physical topologies and connection systems. It defines rules concerning types of cables and access sockets (telecommunications and multimedia), distance restrictions and the physical layout of a network. In order to describe this information for customer, specific denotation is used, e.g. 10BaseT.
The initial number denotes the network's speed expressed in millions bits per second. 10BASE-5 network reaches speed of 10 million bits per second. For 100BASE-T4 network it is 100 million bits per second.
The second part of the name informs about type of transmission: BASEBAND or BROADBAND. In the case of the baseband, the original signal is transmitted with the original frequencies. For example, for 10BASE-T network, frequency amounts to ca. 7.5 MHz. The broadband allows undisturbed transmission of more signals, such that frequency ranges do not overlap. The last number of the name is the maximum length of a cable section expressed in hundred meters. In 10BASE-5 the maximum length of a cable section is 500 m, although, as in every rule, there are exceptions:

10BASE2	Here, the maximum length of a cable section is 185 m, not 200 as is indicated in the name.
10BASE-T	Letter T means that the transmission medium is a twisted-pair cable.
100BASE-T4	This network requires four twisted pairs. All the four pairs are used for transmission as well as reception.

3.3. IEEE 802 Design

Purpose: To create widely accepted standards and engage manufacturers' resources in creating a mass market of standardized products. A5 technology accepted by ANSI in 1985 and by ISO in 1987 as part of the project 8802. These organizations created new working groups, disbanding some of existing ones. The table below presents a review of working groups and subcommittees.

IEEE 802.1	Higher layer interface, bridging and network management
IEEE 802.2	Logical link control-inactive
IEEE 802.3	CSMA/CD (Ethernet)
IEEE 802.4	Token Bus-disbanded
IEEE 802.5	Token Ring-inactive
IEEE 802.6	Metropolitan Area Networks-disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable-disbanded
IEEE 802.8	Fiber Optic Technical Advisory Group-disbanded
IEEE 802.9	Integrated Services LAN-disbanded
IEEE 802.10	Interoperable LAN Security-disbanded
IEEE 802.11 a/b/g/n	Wireless LAN (WLAN) and mesh topology (Wi-Fi Certification)
IEEE 802.12	Demand priority-disbanded
IEEE 802.13	Used in 100Base-X Ethernet
IEEE 802.14	Broadband networks based on cable television-disbanded
IEEE 802.15	Wireless Personal Area Networks (WPAN)
IEEE 802.15.1	Bluetooth Certification
IEEE 802.15.2	Coexistence IEEE 802.15 and IEEE 802.11 Standards
IEEE 802.15.3	Certification of Fast Personal Area Networks (WPAN)
IEEE 802.15.4	Certification of Slow Personal Area Networks (WPAN)
IEEE 802.15.5	Mesh Network for WPAN
IEEE 802.16	Broadband Wireless Access (WiMAX certification)
IEEE 802.16.1	Local Multipoint Distribution Service
IEEE 802.17	Resilient Packet Ring
IEEE 802.18	Radio Regulatory Technical Advisory Group
IEEE 802.19	Coexistence Technical Advisory Group
IEEE 802.20	Mobile Broadband Wireless Access
IEEE 802.21	Mobile Independent Handoff
IEEE 802.22	Wireless Regional Area Network
IEEE 802.23	Emergency Service Working Group

Ethernet is a network standardized as IEEE 802.3. This is a combination of Ethernet version using twisted-pair cable for connecting end systems to network and optical fiber cables creating local structured networks. This is currently the most common wired LAN technology. As technology is developing all the time, the Ethernet is developing as well.

10BaseT Ethernet was developed in 1990 as part of 802.3i group. The standard used twisted-pair unshielded cable (UTP) as a transmission medium. 100BASET network was developed in 1995 by 802.3u group. Officially, it is called 100BASET or 100BASEX network, but it is more commonly known as FAST ETHERNET. FAST ETHERNET Nomenclature depends on the type of transceiver used.

Transceiver is a part of network interface card with circuits necessary for sending and receiving signals through physical medium.

100BASETX	100Mbps through two pairs
100BASE T4	100Mbps through four pairs
100BASE Fx	100Mbps through two-fiber optical cable

3.4. Gigabit Ethernet

Gigabit Ethernet uses the Ethernet protocol, but is ten times faster than Fast Ethernet (1000 Mbps, which is 1 Gbps). Gigabit Ethernet makes it possible to increase the speed of Ethernet from 10/100 Mbps at a computer station through 100 Mbps in cable vertical run and up to 1000 Mbps in data centers.

1000BASE-T network uses four pairs in a full-duplex two-way transmission. Every transceiver also carries out complex digital processing of signals in order to eliminate Near End CrossTalk and echo.

For 1000 Mbps bandwidth, every pair is treated as a separate channel with 250 Mbps bandwidth, operating in an available 100MHz band range. There are two additional parameters that influence the channel capability for Gigabit Ethernet: return loss and Equal-level Far End Cross Talk.

Because every pair in a 1000BaseT network cable provides a two-way transmission, discrepancy in the components' impedances causes signal return (echo), which manifests itself as disturbances at the receiver. Although these disturbances are eliminated by the hardware, they contribute significantly to the total of disturbances at the channel.

Impedance mismatch of a connector dominates at high frequencies, and impedance mismatch between an interconnect cable and a cable dominates at low frequencies.

3.5. 10 Gigabit Ethernet

10 Gigabit Ethernet was formally accepted as IEE 802.3 standard for Ethernet in July 2002. This technology is a next step toward the better performance and functionality of corporate networks and service provider networks, because it combines the multi-gigabit bandwidth with intelligent services, creating scaled, intelligent, multi-gigabit networks with network connections from 10 up to 10,000 Mbps.
10 Gigabit Ethernet has many potential applications in service provider networks, as well as in corporate networks. In order to make introduction of 10 Gigabit Ethernet into the networking market easier and quicker, the 10 Gigabit Ethernet Alliance was created. It was set up by the leaders of networking market: companies 3Com, Cisco Systems, Extreme Networks, Intel, Nortel Networks, Sun Microsystems and World Wide Packets. Moreover, the Alliance supports the Ethernet IEEE 802.3 Committee and the development of 802.3ae standard, as well as promotes the cooperation of 10 Gigabit Ethernet products.

The introduction of 10 Gigabit Ethernet may include:

- very fast connections between buildings, groups of buildings and connection points,
- aggregation of many 1000BASE-X or 1000BASE-T network sections into connections receiving 10 Gigabit Ethernet;
- connections between switches and servers;
- connections between servers creating server groups.

3.6. 40/100 Gigabit Ethernet

The latest technology was defined by IEEE 802.3ba-2010. Working document that specifies parameters for category 8.1 and 8.2 (ISO-IECJTC1 SC25_N2238_25N2238_DTR_11801-99-1_IT 2013-12-05) is the basis for prepared category 8 standard dedicated for 40 Gigabit Ethernet data transmission systems.
In PN-EN 50173-1:2011P standard, tables F.4 and F.5, there are definitions of requirements regarding maximum lengths and attenuations for OM3-OM4 and OS1-OS2 optical fiber cables, so that they can be used for 40/100 Gb transmission. 40 GbE transmission requires 8 fibers (4 channels, 10Gb each); 100Gb transmission requires 20 fibers (10 channels, 10Gb each). Section 8.10 defines new connectors with more than two optical fibers (12 and 24 fibers).

3.7. Horizontal Cabling System

Horizontal cabling system connects patch panels in distribution point cabinets with telecommunications (multimedia) outlets to working stations and other equipment. It can be installed horizontally or vertically. Horizontal cabling system consists of 2 basic elements:

1. Horizontal cables and connecting equipment;
2. Horizontal patchways and installation spaces – mounting system.

Maximum length of a horizontal cable is 90 m, 10 m of which is allocated for interconnect cables in the working area and crossover cables in distribution points. Horizontal cabling does not include the cabling of working area (interconnect cables) or distribution points cabling (crossover cables) that are used for connecting telecommunications equipment at one of the ends of horizontal cabling. Nevertheless, the working area and distribution points cabling influence the performance of the whole channel and have to be included during the planning of every installation. Horizontal cables connect telecommunications outlets with horizontal cabling termination point. Dedicated 100-Ohm twisted-pair cable with four pairs connects each of the telecommunications outlets with patch panel socket. It is recommended that there is such a quantity of cables that the usable area is used to the maximum. This makes the shifts, extensions and changes easier, but it is not always enough for development and fresh cabling installation might be needed. It is recommended that the same number of cables is routed to every working area and that at least two excess horizontal cables per working area are provided in order to fulfill the current and future demand for services. Maximum length of Cat 6 (6A) cable used in 10/100/1000BASE-T (10GBase-T) amounts to 100 m – consisting of: 90 m of twisted-pair solid-conductor cable between patch panel in distribution point and telecommunications outlet; 10 m of crossover and interconnect cables made of stranded conductors. Since stranded-conductor cable attenuation is higher than solid-conductor cable attenuation, exceeding the acceptable 10 m of a crossover cable will lead to reduction of acceptable length of a horizontal cable. It is recommended that the minimum of excess cable is provided. 3 meter excess cable (wrapped in the shape of 8) in a distribution room and 30 cm excess in telecommunications outlet is recommended. The excess cable is included in a 90 m horizontal length limit. The excess will allow making necessary repairs and switches.

3.8. Cable Channel Filling

Patchways have to include cabling components with necessary mechanical and environmental protection (during installation and operation).

It is recommended that horizontal cable channels should be filled to maximum 53% in the case of one cable, 31% in the case of two cables and 40% in the case of three and more cables.

There can be up to two 90° curves along a cable channel. If more than two 90° curves are needed, pull box has to be installed between sections containing two or less curves. Every sharp ends and edges have to be properly protected, so that they will not damage the cables.

A cable channel should be labeled and have a plastic or nylon string for pulling that can sustain at least 90 kg.

Every cable should be properly and individually labeled according to ISO/IEC 11801, 2nd Edition or ANSI/TIA/EIA-606-A.

Remember that sharing one horizontal cable containing four twisted pairs for different purposes is not allowed because of incompatibility of signals and/or applications that require all of the four twisted pairs.

3.9. Cable Allocation

If signal cables and power cords are laid in the same cable channel, bus or cable tray, there must be a physical separator.
Details on normal distances between cables and instructions are included in PN-EN 50174-2 standard.

3.10. Horizontal Cable, 90 m Section

Accurate instructions on distances between low voltage and electrical systems, including the type of telecommunications and computer cable used, as well as instructions on the number of neighboring power cables and the type of lines are specified in chapter 6 of PN-EN 50174-2: 2009 standard.
The above standard provides the rules of establishing recommended minimum distances, which take into account
Resistance of telecommunications and computer cables specified for:
Shielded twisted-pair cables as coupling attenuation, which in the case of the best shielded cables amounts to 80 dB, which at the same time informs about segregation classification at the highest level, which is d;

Unshielded twisted-pair cables as transverse conversion loss (TCL);

Coaxial and twinaxial cables as screening attenuation;
- Power cable structure;
- Quantity and type of neighboring power circuits;
- Separators (and their types) between telecommunications, computer and power cables.

The basic formula for distance between systems is:

$$A = S * P$$

Table 4 specifies the minimum segregation of cable routes „S" depending on telecommunications and computer cables used, according to segregation classification (a, b, c and d; a - worst, d – best) and material used in cable channels (segregation without electromagnetic barrier, open metal cable tray, perforated metal tray, solid metal tray).
Table 5 specifies P (power cabling factor) which depends on the number of basic circuits, i.e. 20 A 230 V.
As an example:
For number of basic circuits from 1 to 3, P factor is 0.2; for number of basic circuits from 13 to 15, P factor is 1.
For example, three-phase circuit 400 V and 40 A includes six basic circuits.
There is an exception to the above rule if:

- the power supply is a one-phase circuit of maximum 32 A;
- according to classification, system environment is E1;
- segregation classification of telecommunications and computer cables used b, c or d.

3.11. Structured Network Connections

In the case of horizontal routes and backbone network cabling routes there are the following rules of allocation that apply:

- Minimum distance from fluorescent, neon, mercury-vapor and gas-discharge lamps amounts to 130 mm;
- Minimum distance from equipment producing electric arc is 800 nm;
- Minimum distance from frequency induction heating equipment is 1000 mm.

If there are routes through firewalls, it is possible to reduce the segregation distance according to the Standard.

3.12. Installation in Temperatures Lower than 0°C

Minimum temperature for cable installation is 0°C. If a cable has to be installed in a lower temperature, it is vital that the following safety measures are applied to avoid cable sheath cracking:

- The cable should be stored in temperature above 10°C for 24 hours before the installation and collected no earlier than four hours before the installation.
- Thus the cable will retain the heat that will prevent it from cracking.
- Cables not installed within four hours should be taken back to the heated room.
- The excess cable should be rolled in a loop 25-31 cm in diameter. If it is rolled too tightly, its sheath may crack. Cables are normally terminated in the telecommunications and computer sockets after the room is closed and heating turned on. Cables are not to be terminated in temperatures below 0°C.

3.13. Minimum Bend Radius

During installation, rules regarding bend radius have to be complied with.

Mechanical Properties		
Minimum Bend Radius	During Installation After Installation	8 x Ø 4 x Ø
Temperature Range	During Operation During Installation	-20°C to +60°C 0°C to +50°C

Caution: Exceeding the minimum bend radius may result in distortion of cable geometry and decline in transmission performance. Restoring the proper bend radius may not correct the fault. If a cable segment has been damaged, it is best to replace it. Minimum acceptable bend radius during installation is higher than in the final position, when the cable is free from any tensions. The requirements regarding bend radius contribute to reduction of bending influence on transmission parameters through installed cable ducts.

There are two typical places, where minimum bend radius may be exceeded::

At telecommunications (multimedia) outlet: after terminating, the excess cable is often jammed into the outlet or, worse, wrapped and shoved into the outlet. It is better to carefully insert the remaining cable through the outlet back into the wall. In distribution point and during routing cable to the patch panel. Previous cable laying practices allowed fitting the cable tight to the cable route (cable tray or rack). It is better to lay cable in gentle curves along the cable route, without sharp bends and changes in direction.

3.14. Tensile Strength

Maximum Tensile Strength of horizontal cable with four pairs of conductors amounts to 100 N.

Excessive tensile strength may occur during installation, when too many cables are pulled or if cables are pulled through a cable drum collar. It is best to replace damaged cables. In order to avoid excessive tensile strength it may be necessary to pull cables in stages.

3.15. Markings

Installed cables should be marked at both ends. Wrap-around printed cable labels are recommended.

3.16. Earthing

Important: This instruction is not a complete earthing installation manual. A fitter has to comply with local regulations. In Poland PN-EN 50310 : 2011 standard (Application of equipotential bonding and earth connections in building with installed computer equipment) is recommended. Fixed earthing infrastructure is defined as independent from telecommunications cabling.

Due to safety reasons, all the cabinets with cabling and equipment must have earth connections through independent earth cables. Every metal elements of a cabinet must be connected to its frame through proper earth cable.

Parallel connections of cabinets to create earth connections is not allowed. Each cabinet should be equipped with an earth unit in the form of an earthing terminal, to which every earth cable is routed. Every shielded panel must be earthed through connection to earthing clamp of a cabinet. Parallel connections of patchboard's earthing units are not allowed.

3.17. Distribution Room

Distribution room includes equipment, cabling and patch panels which are used to create connections and administration between backbone building cabling, equipment cabling and horizontal cabling.

3.18. Cabinets

According to PN-EN 50174-1, location of cabinets, frames and racks should fulfill the following requirements during installation:

- Possibility of conducting further measurements, repairs, development or expansions of installed cabling, without a risk of damage;
- Compatibility with the surface, load of the flooring and other services necessary for computer equipment;
- Space no less than 1.2 m at each area that needs an access;
- Allowing installation of additional cabling without serious disturbances.

Cabinets, frames and racks should not be installed:

- In a bathroom or kitchen;
- At emergency routes;
- On the ceiling or under the floor;
- In cabinets or enclosures with fire hose reels or other fire extinguishing equipment;
- In rooms where there is a risk of flooding.

Structure and size of cabinets, frames and racks along with the spacing should provide:

- Possibility of installing the initial number of cables and retaining the minimum bend radius (if there are many types of cables, the highest of the minimum bend radii applies);
- The installation of elements for management of installation cables and crossover cable;
- Proper earthing of active and passive equipment;
- Proper ventilation of installed equipment;
- Proper segregation requirements of PN-EN 50174-2 chapter 6.

Recommended distance between mounting bars of equipment and closed door is 70 mm. All the trays inside the cabinet should be mounted 100-300 mm from the rear patchboard.

1. The assembly of cabinets should start from the bottom and continue upwards.
2. There should be enough space left for cables management between panels.
3. The panels should be mounted with included mounting screws.

For more information about cabinets, see section 5.8.

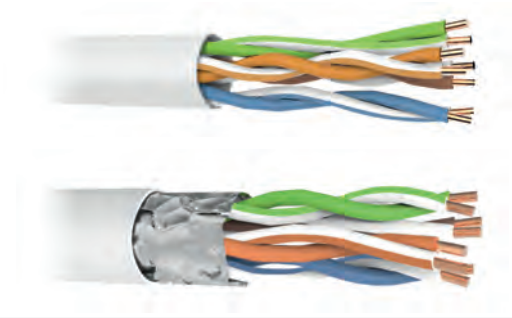
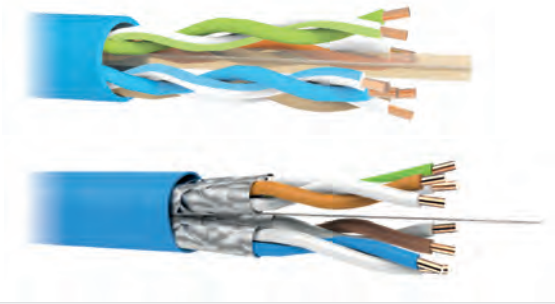
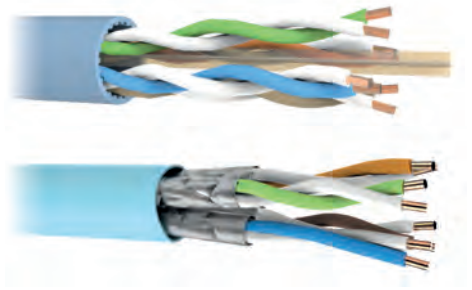
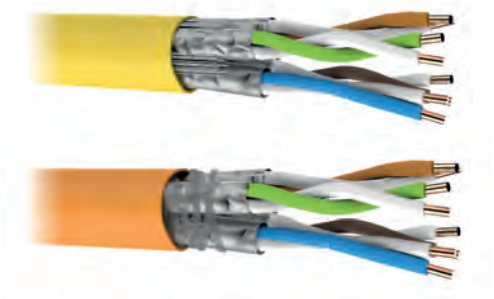
4. Certified DRAKOM Structured Cabling System by BKT Elektronik - Review of the Solutions

BKT Elektronik offers a wide range of universal and reliable copper and optical fiber cables for computer and telecommunications infrastructure. Thanks to many years of experience in production and distribution we have the significant market share. DRAKOM Structured Cabling System by BKT Elektronik for computer and telecommunications networks has been made especially to meet the needs of data transmission. It combines high bandwidth and cable flexibility, which optimally fulfills the future requirements of customers from industry, trade and services sectors. Cabling by BKT Elektronik may be used in standardized as well as non-standard networks.

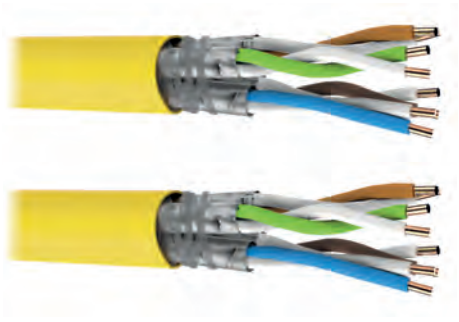
4.1. Copper Cables of Categories 5e to 8.2

DRAKOM BKT 275 –BKT 2000

This extensive range of cables based on four-twisted-pair cable of categories ranging from 5e through 6 up to patented multimedia cables structure-categories 6_A, 7, 7_A and 8.2-has been adjusted to various applications and provides the highest transmission speeds.

	Types	Freq. (MHz)	EN 50173	ISO/IEC 11801
	BKT275 BKT285	100	Cat. 5e class D	Cat. 5e class D
	BKT405 BKT455	250	Cat. 6 class E	Cat. 6 class E
	BKT505 BKT585	500	Cat. 6_A class E_A	Cat. 6_A class E_A
	BKT695 BKT1000	600	Cat. 7 class F	Cat. 7 class F

4.1. Copper Cables of Categories 5e to 8.2

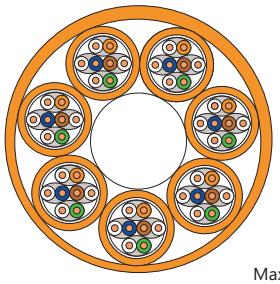
	BKT1200 BKT1500	1000	Cat. 7_A class F_A	Cat 7_A class F_A
	BKT.NL 1500 6P MULTIMEDIA	1000	MULTIMEDIA	Cat 7_A class F_A
	BKT.NL 1500 TV/SAT MULTIMEDIA	1000	MULTIMEDIA TV/SAT	Cat 7_A cass F_A
	BKT.NL 1600	1600		Cat 8.2 class 2*
	BKT.NL 2000	2000		Cat 8.2 class 2*

*according to IEC 61156-9:2014-04 multicore and symmetrical pair/quad cables for digital transmission-part 9. Cables for horizontal floor wiring with transmission characteristics up to 2 GHz.

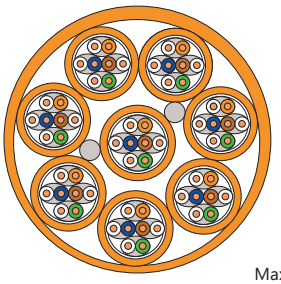
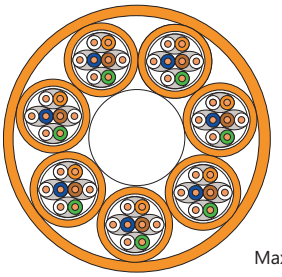
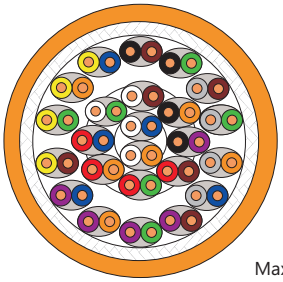
4.2. Copper Cat 7 Cables for Data Centers

DRAAKOM 4DC Solutions for Data Centers

Since 40/100 Gigabit Ethernet is becoming more and more popular, BKT Elektronik expands the range of products with multicore Cat 7 cable (8xAWG23) that fulfills the current requirements concerning cables density in data centers. It will make easier the transition to 40/100 Gigabit Ethernet-next generation network.
The forthcoming new sheets of EN 50600 concerning telecommunications infrastructure (2-4) recommend the use of pre-terminated cabling for solutions with higher reliability and safety (Classes 3 and 4 according to EN 50600-1).

	Types	Freq. (MHz)	EN 50173	ISO/IEC 11801 2nd Ed.
 Maximum range up to 80 m	6x4P 23	600	Cat 6_A class E_A	Cat 6_A class E_A

4.2. Copper Cat 7 Cables for Data Centers

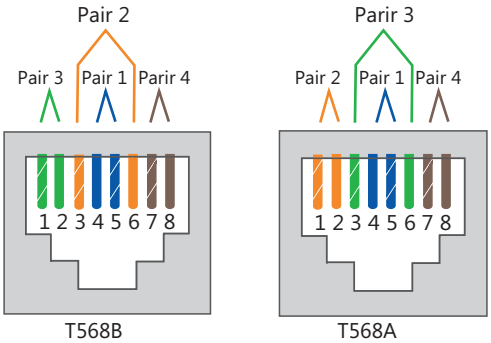
 Maximum range up to 80 m	8x4P 23	600	Cat 6_A class E_A	Cat 6_A class E_A
 Maximum range up to 60 m	6x4P 23	600	Cat 6_A class E_A	Cat 6_A class E_A
 Maximum range up to 60 m	24P 26	600	Cat 6_A class E_A	Cat 6_A class E_A

DRAKOM from Cat 5e to Cat 7_A–modular components for the highest network performance

The wide range of telecommunications and computer products by BKT Elektronik perfectly complements the current cabling solutions
that are commonly used in many systems. It also includes: copper telecommunications and computer products with performance typical of classic category 5e, products from popular category 6, 10 Gbps products from the best category 6A and even category 7A, the latest optical fiber cables by BKT Elektronik coated through plasma spray-physical vapor deposition (PS-PVD) and additional modular optical fiber solutions upgraded in terms of durability and flexibility.

4.3. Telecommunications and Computer Cables Termination

All copper twisted-pair cables have to be terminated in telecommunications (multimedia) outlet of the same or higher category. Every connection which replaced a lower category component is automatically classified to this lower category (class). During shielded cables termination you should follow the same rules as in the case of U/UTP cables. What is more, in order to retain continuity and efficiency of shielding from cable to outlet, you can make the shield termination of thin foil and protective conductor. In order to retain continuity, installation manual by BKT Elektronik is to be followed. Bridging, splitting and splice connections are not allowed according to the requirements concerning copper horizontal cabling. A fitter must be acquainted with DRAKOM RJ45 modules installation manual. Proper tools, conductor arrangement and cable stripping length are critical, especially in Cat 6A systems. Keystone sockets usually apply the conductor color coding, which may be done according to T568A or T568B standard. The



4.3. Telecommunications and Computer Cables Termination

Telecommunications sockets

	Type	Freq. (MHz)	EN 50173	ISO/IEC 11801
	Keystone Module BKT DRAKOM RJ45 unshielded, cat 5e toolless Keystone Module BKT DRAKOM RJ45 shielded, cat 5e toolless	100	Cat 5e class D	Cat 5e class D
	Keystone Module BKT DRAKOM RJ45 unshielded, cat 6 toolless Keystone Module BKT DRAKOM RJ45 shielded, cat 6 toolless	250	Cat 6 class E	Cat 6 class E
	Keystone Module BKT DRAKOM RJ45 unshielded, cat 6_A toolless Keystone Module BKT DRAKOM RJ45 shielded, cat 6_A toolless	500	Cat 6_A class E_A	Cat 6_A class E_A
	Module BKT.NL RJ45, shielded, cat 6_A, toolless	500	Cat 6_A/class E_A	Cat 6_A/class E_A
	Module BKT.NL MMC 4P, shielded, cat 8.2, toolless	1600/2000	Cat 7/klasa F Cat 7_A/klasa F_A Cat 8.2/class II	Cat 7/class F Cat 7_A/class F_A Cat 8.2/class II
	Module BKT.NL MMC 6P, shielded, cat 8.2, toolless	1000	Cat 7_A/class F_A	Cat 7_A/class F_A

From the side of the end user, telecommunications and computer outlets should be mounted using elements and equipment required by the Investor or those used for the power supply. Since all the RJ45 modules are in Keystone standard (it is one of the most popular standards on the market), it has fixing elements almost in every equipment system. In order to make the work of designers and fitters easier, document "BKT Elektronik Solution Compatibility and Installation Equipment of Other Producers.doc" has been prepared to help choose these elements quickly and correctly.

4.3. Telecommunications and Computer Cables Termination

From the side of Distribution Point telecommunications and computer outlets should be mounted in modular panels:

	Types
	DRAKOM 19" Modular Shielded Patch Panel, 24xRJ45, 1U, black
	DRAKOM 19" Modular Shielded Patch Panel, 24xRJ45, 1U, black, shifted ports
	DRAKOM 19" Modular Shielded Patch Panel, 24xRJ45, 1U, black, angled ports
	DRAKOM 19" Modular Shielded Patch Panel, 48xRJ45, 1U, black
	19" BKT.NL Modular Shielded Patch Panel, 24xMMC 4P, 1U, black
	19" BKT.NL Modular Shielded Patch Panel, 48xMMC 4P, 1U, black
	19" BKT.NL Modular Shielded Patch Panel, 16xMMC 6P, 1U, black
	19" BKT.NL Modular Shielded Patch Panel, 32xMMC 6P, 2U, black

4.4 Range of DRAKOM Components for Horizontal Cabling

Copper cabling solution based on quad cables for data transmission with a modular system of telecommunications (multimedia) outlets creates a perfect base for the installation of networks compliant with ISO/IEC 11801, EN 50173 and EIA/TIA 568A standards. They are used for fast data transmission – mainly in vertical cabling and horizontal cabling of standardized Local Area Networks (LAN) of the following types: Token Ring, Ethernet, ISDN, TPDDI, Fast-Ethernet 100Base-TX for ATM, Gigabit-Ethernet, 1000Base-T, 10GBase-T and CATV. All the shielded cabling products from BKT695 series and higher are compatible with 10 Gigabit Ethernet technology (IEEE802.3:10GBase-T).
BKT275 and BKT285 Cover all the conventional and standardized Cat 5e/Class D cable types up to 100 MHz.
BKT405 and BKT455 Support the trend of creating larger cable reserve based on Cat 6/Class E cables (according to ISO/IEC 11801) up to 250 MHz.
BKT585 and BKT695 The best Cat 6$_A$/Class E$_A$ cables (according to ISO/IEC 11801) up to 500 MHz in compliance with 10G standard.
The names of the components arise from and are consistent with the possible frequency range in transmission. As in the case of a cable, this frequency range may exceed the ranges specified in the above mentioned standards.

Performance level	Associated cable details	Associated Component Details
Class D, unshielded	U/UTP Cat 5e BKT275	DRAKOM RJ45 Unshielded Cat 5e Keystone Module, toolless
Class D, shielded	F/UTP Cat 5e BKT285	DRAKOM RJ45 Shielded Cat 5e Keystone Module, toolless
Class E, unshielded	U/UTP Cat 6 BKT405	DRAKOM RJ45 Unshielded Cat 6 Keystone Module, toolless
Class E, shielded	U/FTP Cat 6 BKT455	DRAKOM RJ45 Shielded Cat 6 Keystone Module, toolless
Class E$_A$, shielded	U/FTP Cat 6$_A$ BKT585 S/FTP Cat 7 BKT695	DRAKOM RJ45 Shielded Cat 6A Keystone Module, toolless
Class F, shielded	S/FTP Cat 7 BKT1000 S/FTP Cat 7$_A$ BKT1200 S/FTP Cat 7$_A$ BKT1500	Module BKT.NL MMC 4P
Class F$_A$, shielded	S/FTP Cat 7$_A$ BKT1200 S/FTP Cat 7$_A$ BKT1500	Module BKT.NL MMC 4P

4.5 Crossover and Interconnect Copper Cables

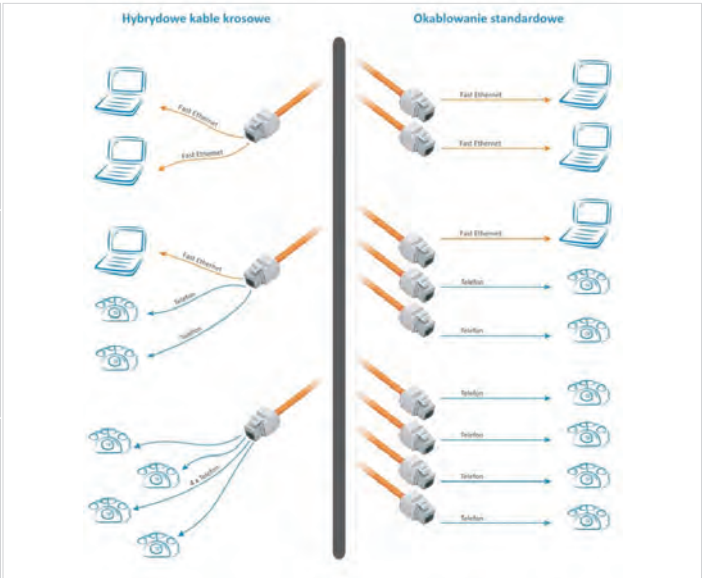
In order to connect end users to a computer network (SCS) you should use crossover at the distribution point and interconnect cables at the telecommunications end outlet. You should use cables of proper category or higher.
The offer includes RJ45-RJ45 cables in 1:1 assignment and hybrid cables that allow increasing the number of provided services. RJ45-RJ45 (referred to as patch cords) are available in colors: grey, green, blue, yellow and red. Standard lengths are 1, 2, 3, 5 and 10 meters.
It is recommended that the coloring matches the proper categories:
Category 5e – grey,
Category 6 – blue, Category 6$_A$ – red,
Category 7 – yellow/orange

Available hybrid cables:

RJ45-2 x 100BaseT Hybrid Cable (36,12/36,12),

RJ45-ISDN100BaseT Hybrid Cable (36,45/12,36),
100BaseT/Tel/Tel Hybrid Cable (12,36/45/45),

RJ45-4xTel Hybrid Cable (45/45/45/45)



There should be used the same type of a hybrid cable at each end of every connection (different lengths can be used though).

For categories 7$_A$ and 8.2 crossover cables are used:
BKT.NL MMC 4P-RJ45 SFTP
Standard lengths are 1, 2, 3, 5 i 10 meters.
Crossover hybrid cables using BKT.NL MMC 4P connectors allow up to four independent applications at one connector with no need for using adapters in the outlet.

4.6 Backbone Subsystems-Multi-pair Cables-Phone Connections

In building and campus backbone subsystems, multi-pair cables are still used for the purposes of phone connections.

In the case of connections between distribution points located in the same building, we use 25-, 50- and 100- pair indoor shielded or unshielded cables. 50/25-port ISDN patch panels in local/floor distribution points are recommended for termination of these connections (ports in these panels are compatible with 8-pin RJ45 connectors, one or two pairs may be terminated in each port from the side of the cable). It is also possible to terminate multi-pair cables in LSA modules mounted on proper panels in 19" standard (1U panel for 6 LSA modules; 2U for 9; 3U for 15 or 20; 4U for 18).

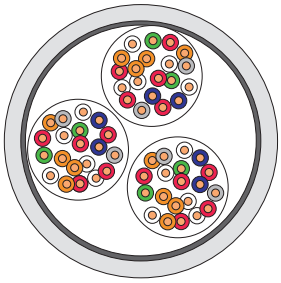
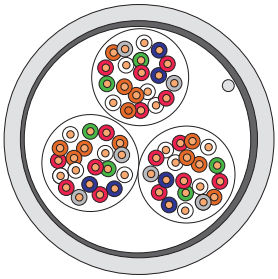
LSA connectors are recommended at the main distribution frame of a building.

In the case of connections between distribution points located in different buildings, the type of cable used depends on its operating conditions. Cables operating in a wider range of temperatures and resistant to moisture, sunlight and rodents should be used most frequently.

In all cases connections between buildings through multi-pair cables should be terminated in LSA disconnection modules with surge arresters. Always remember about proper earthing of these arresters because only in this way do they provide proper protection of devices against surges that occur mainly as a result of atmospheric discharges.

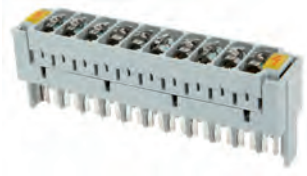
It is a very important element, which is necessary for proper protection of an expensive equipment in the form of a telephone exchange.

Backbone Subsystem Elements-Multi-pair Connections

Type	Category A	Category B
	UTP Cat 3 Cable, 25x2x0,5, 50x2x0,5 and 100x2x0,5	DRAKOM UTP Cat 3 Cable 25x2x0,5 LSOH (J-2YH), DRAKOM UTP Cat 3 Cable 50x2x0,5 LSOH (J-2YH), DRAKOM UTP Cat 3 Cable 100x2x0,5 LSOH (J-2YH)
	FTP Cat 3 Cable 25x2x0,5, 50x2x0,5 and 100x2x0,5	DRAKOM FTP Cat 3 Cable 25x2x0,5 LSOH (J-2YH), DRAKOM FTP Cat 3 Cable 50x2x0,5 LSOH (J-2YH), DRAKOM FTP Cat 3 Cable 100x2x0,5 LSOH (J-2YH)
	Telephone Patch Panel	DRAKOM 19" Patch Panel, ISDN, 50xRJ45, 1U, cable organizer
	ISDN Telephone Patch Panel	19" Patch Panel DRAKOM, ISDN, 25xRJ45, 1U, cable organizer
	Module	LSA Disconnection Module, 10-pair, for backmount frame

4.6 Backbone Subsystems-Multi-pair Cables-Phone Connections

Backbone Subsystem Elements - Multi-pair Connections

Type	Category A	Category B
	19" Frame	1U 6xLSA,2U 9xLSA, 3U 15xLSA,4U 18xLSA
	Indoor box	30 pairs, flush-mounted; 50 pairs, flush-mounted; 100 pairs, flush-mounted
	Magazine	3P SURGE ARRESTER MAGAZINE
	3P Surge Arrester	3P SURGE ARRESTER FOR LSA MAGAZINE

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

For fast data transmission in building and campus backbone subsystems optical fiber cables are used. The recent amendment to the Ordinance of the Minister for Infrastructure on required technical conditions of buildings and their location (www.snb.org.pl Current Technical Conditions [pdf] section 8a) introduces requirements for specific buildings of using single-mode optical fiber cabling in commercial premises.
Take into account also whether the connection will be made within a building or between buildings.
We can use indoor or universal optical fiber cables for connections between distribution points within one building. Universal or outdoor cables should be used for connections between buildings.

- All fibers of optical fiber cables should be terminated in optical fiber connectors (specified in standards) in 19" or wall-mounted distribution boxes.
- Fibers in multi-mode optical fiber cables have a special structure that increases bending capabilities with no impact on attenuation parameters.
- Typical quantities of fibers in optical fiber cables used for backbone connections in SCS are 4, 6, 8, 12, 16 i 24.

Types of fibers used and their designations in:

Multi-mode cables:

- OM1-G62,5/125
- OM2-G50/125
- OM3-G50/125 OM3
- OM4-G50/125 OM4

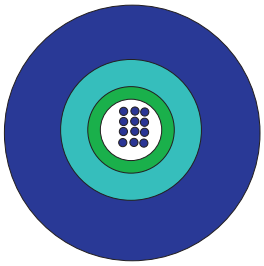
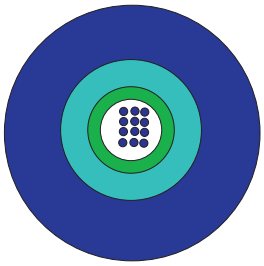
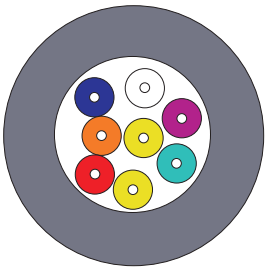
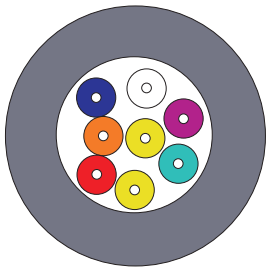
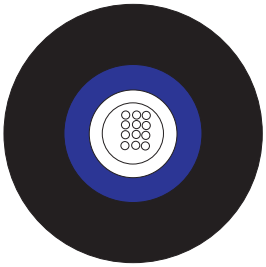
- Single - mode cables-OS1-E(J)9/125
- And with water peak-OS2-E(J)9/125
- All the single-mode cables are in OS2 version.
- Normally a transmission channel is comprised of 2 fibers.

The length of a connection in every application is restricted in order to retain high transmission speed. Recommended length limits in various types of LAN are presented in the table below

Application	Connection Length	Specification Sheet of a Fiber Type
10 Mbit IEEE 802.3 i ISO/IEC 8802-3	OM1: 62,5 µm: 2000 m OM2: 50 µm: 1514 m OM3: 1514 OM4: 1514 m	C02 C01a, C23, C34 C12, C31 C11,C32
100 Mbit IEEE 802.3 i ISO/IEC 8802-3 100BaseFX (1300 nm)	OM1: 62,5 µm: 2000 m OM2: 50 µm: 2000 m OM3: 2000 m OM4: 2000 m	C02 C01a, C23, C34 C12, C31 C11, C32
1 Gbit IEEE 802.3 1000BaseSX (850 nm)	OM1: 62,5 µm: 275 m OM2: 50 µm: 550 m OM3: 1000 m OM4: 1100 m	C02 C01a, C23, C34 C12, C31 C11, C32
1 Gbit IEEE 802.3 1000BaseLX (1300 nm)	OS2: 5000 m OM1: 62,5 µm: 550 m OM2: 50 µm: 550 m OM3: 550 m OM4: 550 m	C03e, C06e, C24 C02 C01a, C23, C34 C12, C31 C11, C32
10 Gbit IEEE 802.3ae 10GBase-SW/SR (850 nm)	OS2: - OM1: 62,5 µm: 33 m OM2: 50 µm: 82 m OM3: 300 m OM4: 550 m	C02 C01a, C23, C34 C12, C31 C11, C32
10 Gbit IEEE 802.3ae 10GBaseLX4 (1300 nm)	OM1 62,5 µm: 300 m OM2 50 µm: 300 m	C02 C01a, C23, C34 C12, C31 C11, C32
10 Gbit IEEE 802.3ae 10GBase-L (1310 nm)	OS2: 10000 m	C03e, C06e, C24
10 Gbit IEEE 802.3ae 10GBase-EW/ER (1550 nm)	OS2: 30000 m OS2: 40000 m	C03e C06e, C24
40 Gbit IEEE.ba 40GBase-SR4 = 4x10 Gbit(850 nm)	OM3: 100 m OM4: 150 m	C12, C31 C11, C32
40 Gbit IEEE.ba 40GBase-LR4 = 4x10 Gbit (1300 nm ITU G.694.2 CWDM)	OS2: 10000 m	C03e, C06e, C24
100 Gbit IEEE.ba 100GBase-SR10 = 10x10 Gbit (850 nm)	OM3: 100 m OM4: 150 m	C12, C31 C11, C32
100 Gbit IEEE.ba 100GBase-ER4 = 4x25 100GBase-LR4 = 4x25	OS2: 10000 m OS2: 40000 m	C03e, C06e, C24 C06e, C24

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

The most common types of optical fiber cables:

Section	Designation	Application
	U-DQ(ZN)BH LSOH 1000N E14	Universal (outdoor/indoor)
	U-DQ(ZN)BH LSOH 1500N E10	Universal (outdoor/indoor)
	I-V(ZN)H Mini-Breakout 280-400N D02 TIGHT	Indoor
	I-V(ZN)H Mini-Breakout 500-1500N D12 TIGHT- tight-buffered/universaly	Indoor
	IA-DQ(ZN)B2Y 1500N E08	Outdoor

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

IEEE 802.3ba 40G/100G Ethernet standard was ratified in June 2010r.

	IEEE	Designation	Mbits/sec	Fiber type	Number of fibers	Maximum link length (in meters)	Maximum channel insertion loss (in dB)
10-Gbit Ethernet	802.3ae	10GBase-SR	10,000	OM3	2	300	2.6
40-Gbit Ethernet	P802.3ba	40GBase-SR4	40,000	OM3	8	100	1.9
40-Gbit Ethernet	P802.ba	40GBase-SR4	40,000	OM4	8	150	1.5
100-Gbit Ethernet	P803.2ba	100GBase-SR10	100,000	OM3	20	100	1.9
100-Gbit Ethernet	P802.3ba	100GBase-SR10	100,000	OM4	20	150	1.5

Source: Cabling & Maintenance

For optical fiber connectors color codes apply:

Multi-mode	beige or black
Single-mode (physical contact-PC)	blue
Single-mode (angled physical contact-APC)	green

According to connector polish we distinguish:

Parametr	Multi-mode	Single-mode	
Polish	PC	UPC	APC
Attenuation	≤ 0,3 dB	≤ 0,3 dB	≤ 0,3 dB
Reflectance	-	≥ 52 dB	≥ 62 dB

Pigtails ends colors

Type	Single-mode UPC	Single-mode OM1	Multi-mode OM1, OM2	Multi-mode OM3, OM4
FC Connector	metallic	metallic	metallic	metallic
FC Sheath	black	black	black	black
LC Connector	blue	green	beige	beige
LC Sheath	white	white	white	white
SC Connector	blue	green	beige	beige
SC Sheath	black	black	black	black
ST Connector	metallic	metallic	metallic	metallic
ST Sheath	black	-	black	black
MTRJ Connector	black	-	black	black
MTRJ Sheath	black	-	black	black
Cable color	yellow	yellow	OM1 Blue OM2 Green	turquoise
Jacket color	yellow	yellow	OM1 Blue OM2 Green	turquoise

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

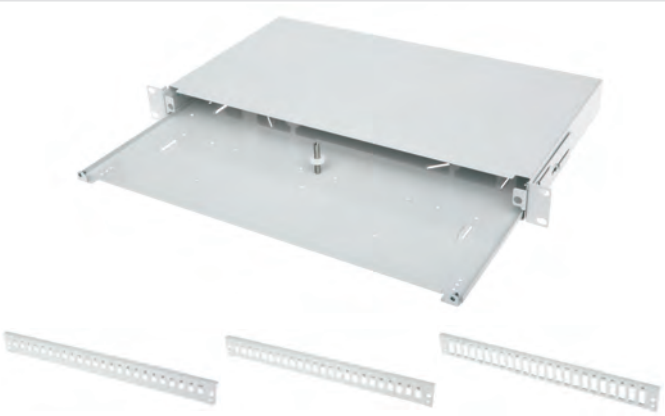
Optical Fiber Adapters and Connectors:

Adapter	Connector/Pigtail	Description
		SC MM and SM
		LC MM and SM
		MTRJ MM and SM
		E2000 MM and SM
 		MPO MM and SM

SC adapters are compatible with LC Duplex, MTRJ and E2000 adapters. SC Duplex adapters are compatible with LC quad adapters.

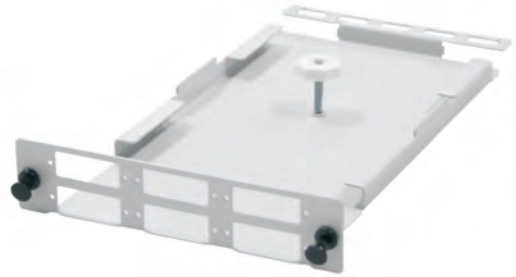
4.7 Backbone Subsystem-Optical Fiber Cables-Fast Data Transmission

Optical Distribution Boxes and Equipment:

Photo	Type	Description
	Veni	1U/19" "Veni" Retractable Optical Distribution Box + 12/24 SC (SC Duplex, ST/FC PC) Front Panel
	Light	1U "Light" Retractable Optical Distribution Box with Integrated 24 x SC (SC Duplex, ST) Front Panel
	Top	1U RAL 7021 Telescopic Retractable Optical Distribution Box with "TOP" Positive Lock and 24 x SC (SC Duplex, ST) Front Panel
	FTTH	BKT 2U/19" 96xSC Simplex (E2000) FTTH Optical Distribution Box

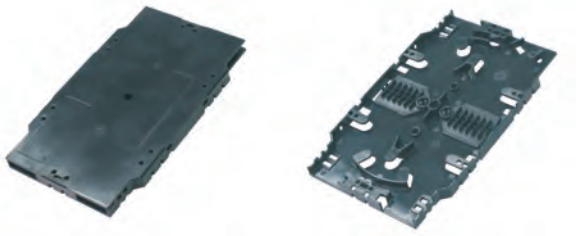
4.7 Backbone Subsystems - Optical Fiber Cables - Fast Data Transmission

Optical Distribution Boxes and Equipment:

Photo	Type	Description
	LGX	BKT 2U/19" 96xSC Simplex (E2000) FTTH Optical Distribution Box
	Alfa module	Alfa 6xSC (SC Duplex, ST/FC) Module
	NSR small	Small Fiber Optics "Data plus" Wall-mounted Distribution Cabinet (IP54 version) + 4/8xSC Duplex 8xST 12xSC Distribution Panel
	NSR medium	Medium Fiber Optics "Data plus" Wall-mounted Distribution Cabinet + 12xSC duplex (ST) Distribution Panel for NSR-S "Data plus" and 24xSC Simplex/MTRJ/ E2000 (ST) Distribution Panel for NSR-S "Data plus"

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

Optical Distribution Boxes and Equipment:

Photo	Type	Description
	NSR large	Large Fiber Optics "Data plus" Wall-mounted Distribution Cabinet + 2U 24xSC duplex (ST/FC/PC) "Data plus" Distribution Panel and 2U 48xSC duplex (SC, ST/FC/PC) "Data plus" Distribution Panel
	Termination Box	BKT Optical Termination Box (2xSC Duplex Adapter)
	Splice Cassette	Optical Splice Cassette + Cover +Two Holders for 6/12 Fiber
	Tubing	QuickFiber (45mm) (61mm) Heat-shrink Aluminum Tubing
	Front Organizer	"Veni" Distribution Box Front Cable Organizer
	Cable Grommet	PG 13.5 (16) QuickFiber Cable Grommet

4.7 Backbone Subsystems-Optical Fiber Cables-Fast Data Transmission

Optical Distribution Boxes and Equipment:

Photo	Type	Description
	ODF Cabinet	BKT Free-standing 42U 19" ODF Cabinet 800(900)/400/1980, French Door
	Outdoor Distribution Box	Free-standing Outdoor Optical Distribution Box 450/920/355 IP55 for 144 Subscriber Lines, Aluminum

Optical fiber connections especially between cabinets using cables terminated in MPO connectors are becoming more and more popular:

Photo	Type	Description
	Veni	1U/19" "Veni" Retractable Distribution Box + 3 x LGX Front Panel with 6 x LC Duplex Cassette
	MPO	MPO/MPO Cable + LGX 6xLC Duplex Cassette (available versions: OM3, OM4 and OS2)

For correct configuration of optical fiber connections remember that MTRJ and MPO connectors are available in male and female versions. At present, the most popular method of making connectors at optical fiber cables is pigtails splicing. Correct cable termination in MTRJ connectors is done by splicing male pigtails (with two protruding centering pins) and using crossover cables terminated from the side of the distribution box in female MTRJ connectors. In the case of connections combined with MPO connectors, order an optical fiber cable of proper length terminated in female MPO connector and use cassettes with male connectors. The choice of path elements is vital for proper crossing over according to selected method.

4.8 Distribution Points-19" Cabinets

Distribution Point consists of equipment, cabling and patch panels, which are used for creating connections and administration between building backbone cabling, equipment cabling and horizontal cabling.

Proper selection of 19" cabinets is very important for providing enough space for current needs, as well as some space reserve for development.
Minimum number of cabinets should be specified on the basis of the quantity of passive equipment (horizontal cabling panels, copper and optical fiber panels for backbone subsystems, crossover cables organizer, trays, power strips etc.) and active equipment, such as UPS, switches and other active devices.

It is good practice to design horizontal crossover cables organizers by every 48 ports - such a system provides proper organization and correct management of connections infrastructure.

If there is a requirement of mounting such equipment as rack servers in cabinets, use proper cabinets with depth of minimum 1000 or 1200 mm. If higher power equipment is installed, a problem of forced ventilation has to be resolved or air conditioning has to be installed, so that optimal temperature (and sometimes moisture as well) conditions recommended by the manufacturers are provided. A separate and quite complicated matter is Data Center design. Chapter 6 briefly describes this issue.

19" Distribution Cabinets and Equipment

Photo	Type	Description
	Rack cabinets	BKT Standing Rack Cabinet Height: 42U/45U/47U Width: 600 mm/800 mm Depth: 600 mm/800 mm/1000 mm Various door versions: Sheet-glass, metal, full glass Load: 600 kg
	Server Rack Cabinet	BKT Standing Server Rack Cabinet Height: 42U/45U/47U Width: 600mm/800mm Depth: 1000mm/1200mm Various versions of perforated doors Load: 1000 kg

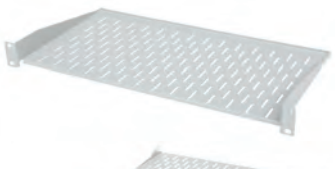
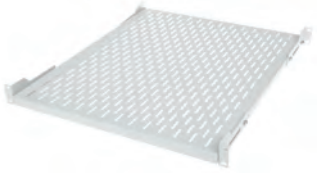
4.8 Distribution Points - 19" Cabinets

19" Distribution Cabinets and Equipment

Photo	Type	Description
	4DC Server Rack Cabinet	BKT 4DC Server Rack Cabinet Height: 42U/45U/47U Width: 600mm/800mm Depth: 1000mm/1200mm Various versions of perforated doors Load: 1500 kg More information in chapter 7
 	Racks	BKT Rack 32U, 42U, 45U, 48U simplexand duplex
   	Hanging Cabinets	Hanging One-piece Cabinet BKT 4U - 21U Top and Standard 600x400 - 600x600 Hanging Two-piece Cabinet BKT 4U - 21U Top and Standard 600x400 – 600x600
	Industrial Cabinets	19" Industrial Cabinet 32U 800x800, 42U 800/1000 IP55

4.8 Distribution Points-19" Cabinets

19" Distribution Cabinets and Equipment

Photo	Type	Description
	Outdoor Cabinets	Various IP55 versions 15U, 22U, 42U 19''-21" One-or two-compartment DASZ-P and DASZ-AL
	Earthing Strip	Earthing Strip
	Bases for Standing Cabinets	For all standing cabinet models
	Ventilation Panels	2-, 4- and 6-fan Top-Rack Ventilation Panel + Thermostat
   	Shelves	2U Shelves with Sliding Tray Fixed Shelves Fixed Shelves Mounted at Four Points 1U Shelves with Adjustable Depth

4.8 Distribution Points-19" Cabinets

19" Distribution Cabinets and Equipment

Photo	Type	Description
	Organizer	DRAKOM 19" 1U Horizontal Cable Organizer
	Cable Holders	40x40, 40x80 and 80x80 Cable Holders

Earthing strips and a set of mounting screws (20 M6 mounting screws + washers + basket nuts). Every cabinet should be properly earthed and have at least one power circuit. Every cabinet with active devices requiring power supply should be fitted with proper strips. Chapter 8 describes issues related to this.

4.9 Network Tests

In order to verify the desired effect of a given designed system, we have to describe and specify in details standards according to which tests are to be conducted after installation. Starting the test, make sure that the tester is fully charged and has up-to-date software. Tests should be made with a dynamic tester that has software allowing the measurement of parameters according to currently applicable standards. The tester should have a current certificate that confirms the accuracy of its indications. It should have Level III accuracy (suggested devices: PSIBER WX4500, MICROTEST Omniscanner, FLUKE DSP-4300 or FLUKE DTX). For tests of Class E_A, F, F_A systems Level IV accuracy testers are required, according to IEC 61935-1 (e.g. PSIBER WX4500, Ideal Lantek II 6_A/7, Fluke DTX1800 and Agilent Wirescope Pro). Tests for certifications are to be conducted with a proper tester with up-to-date factory calibration (all manufacturers require annual factory calibration). Before the test, the tester should be calibrated (reference connection set up)-it is usually done through a proper measurement using Permanent Link and Channel adapters. Next, specify standard according to which the test is to be made (Cenelec EN 50173 is required), class (depends on elements used in the cabling), test type (Permanent Link is required) and NVP values of a tested cable. Accurate NVP value is necessary to specify cable length correctly. It can be found on a cable, in a specification sheet or very often in manufacturers' database stored in a tester.
If it is impossible to specify the correct NVP value, it can be established by testing a cable with known length. We can use a 50 m section of a cable (even 90 m is recommended for more accurate result). Set up a tester to measure NVP and after it is finished, enter the length – on this basis the tester establishes NVP. Having made all the necessary setups, we can commence with the tests. At the end of every test there is a test report of every path (horizontal copper cabling part tests and vertical optical fiber cabling part tests). 100% of proper tests for the given cabling category/class should be made. Particulars connections can be certified and should be measured according to the requirements of the weakest element of a used Link in the following form: receivers telecommunications outlet – twisted-pair cable – telecommunications outlet in a distribution panel.
Every test of a horizontal transmission (copper) path should include:

- Wire Map
- Length
- Resistance
- Capacitance
- Impedance
- Propagation Delay
- Delay Skew
- Attenuation
- NEXT
- ACR
- Return Loss
- ELFEXT
- PS NEXT
- PS ACR
- PS ELFEXT

4.9 Network Tests

Optical fiber part should be tested using proper contact tip or a separate power tester. If contact tips are used for above listed cabling testers, the measurement should be made in "OF-300" configuration.
Optical fiber transmission path test should specify attenuation in two transmission windows: 850 nm and 1300 nm. Attenuation measurement for each optical fiber transmission path should be conducted two-way and in two transmission windows for MM optical fiber cables:

- from point A to point B at 850nm
- from point B to point A at 850nm
- from point A to point B at 1300nm
- from point B to point A at 1300nm

and for SM optical fiber cables:
- from point A to point B at 1550nm
- from point B to point A at 1550nm
- from point A to point B at 1310nm
- from point B to point A at 1310nm

Every test report should include information on the value of operation margin (or safety margin, which is a difference between a standard requirement and the actual test result, it is expressed in units proper for every measured value) given in the worst cases. Transmission parameters should be tested within the entire required range of frequencies. Safety margin has to be included in test report for each separate transmission copper path or each separate optical fiber.

4.10 Network Certification

During the design process it should be specified whether cabling certification is required.

System Warranty-Procedure of Receiving the Warranty

1. System Warranty for DRAKOM Certified Structured Cabling System may only be granted pursuant to the procedure described below.
2. The first step to receive the System Warranty is to send a completed Application Form to BKT Elektronik including basic information concerning the installed system, User, Certified Fitter and start and finish dates.

2.1 In the case of purchases at Distributors and Wholesalers: Application Form before installation of DRAKOM Structured Cabling System, and then after installation has been finished-DRAKOM System Warranty Application.

2.2 In the case of purchases directly at BKT Elektronik DRAKOM System Warranty Application form has to be filled and sent.

3. Applications shall be filled in an electronic form, printed and signed.
4. Filled and signed by a Certified Fitter applications shall be sent to BKT Elektronik Warsaw Branch by mail or courier.
5. Company provides test results in an electronic form.* The test results in a proper format can be sent to BKT Elektronik bz mail or courier on CD/DVD or by e-mail to: pomiary@bkte.pl.
6. Additionally, a copy of test results in a text file format shall be provided (doc. or pdf.).
7. BKT Elektronik reserves the right to inspect the installation during its course and after it has been finished.
8. After the installation has been finished, the following documents shall be sent to BKT Elektronik:

8.1 Signed and stamped set of as-built documentation including schematic design of the system, distribution of end points and location of significant elements of cabling, such as distribution points, consolidation points etc.

8.2 List of installed components with copies of purchase invoices.

8.3 Results of the dynamic tests of copper paths of Permanent Links or Channels and attenuation tests of optical fiber paths conducted in compliance with the applicable standards: EN 50173 ISO/IEC 11801 or ANSI/EIA/TIA 568A/B (as previously specified) in an electronic format of the tester (.prz. .flt, .fcm, .dat, .mdb etc.).

8.4 Current calibration certificate of a tester used in measurements.

9. Only complete materials and correct tests will be subject to Certification.
10. If the system is considered to have been incorrectly installed, the Certified Fitter makes necessary corrections and reports them to BKT Elektronik, after which the date of network inspection is established (the inspection may be chargeable).
11. When a correct system is approved by BKT Elektronik, the System Warranty for DRAKOM Certified Structured Cabling System will be issued in a form of a Certificate.

System Warranty-Warranty Extension Rules

1. If the system covered by the System Warranty for DRAKOM Certified Structured Cabling System is developed or significantly modified, all the modifications have to be approved by BKT Elektronik.
2. New installation, being the expansion of an infrastructure for which System Warranty has already been granted, is considered from the date of the first certification of the System.
3. Expansion of a system subject to approval includes:

3.1. Installation of new outlets.

3.2. Installation of new distribution points.

3.3. Backbone connection of several local networks.

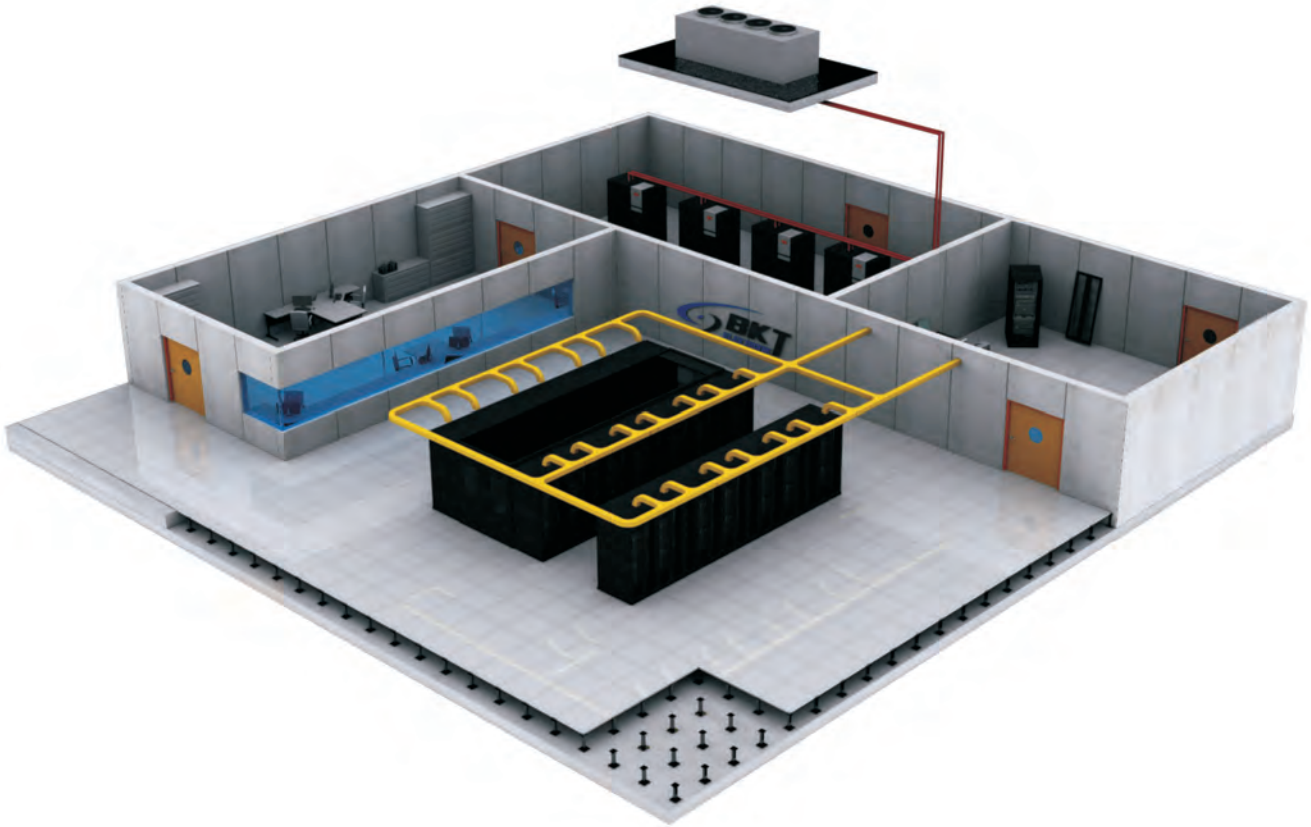
3.4. Other modifications to the original subject of the Warranty.

4. The approval of modifications and the extension of the warranty by BKT Elektronik is only possible if a Certified Fitter complies with the Warranty Extension procedure.
5. If it has been proven that any modifications or expansion of a system subject to warranty has been made without the approval of BKT Elektronik, the 25-year warranty shall cease to apply and BKT Elektronik will withdraw from warranty reinsurance.
6. BKT Elektronik reserves the right to refuse to approve system expansion, which has been incorrectly designed and performed.

Today, it is unquestionable that the access to information has become a key element which is crucial in a company success. Assignment of a special room which constitutes a heart of telecommunications and computer system of an institution has turned out to be necessary.
Data Centers has become the key for undisturbed storing and sharing of data in a company.

In order to meet the arising needs, BKT Elektronik, drawing upon its experience, knowledge and support of many qualified partners, has created this manual to explain the subject of Data Center design.

Continually increasing demand for power necessary for IT equipment and the necessity of using more efficient cooling solutions and scalable infrastructure which can catch up with the pace of business development have become a cause of a worldwide crisis in Data Centers. Today, problems with power supply, cooling and lack of free space in the existing Data Centers are the main reasons that make the installation of new IT equipment impossible, and as a result creating a barrier in business development.



5.1. Standards

Construction of an object designed for Data Center

The following ordinances specify the required technical conditions for buildings and their equipment, their location at a plot of land and development of land for building, pursuant to the Building Code.

- ACT of 7 July 1994 – Building Code (Journal of Laws No. 156 of 2006, item 1118) (Amendments: Journal of Laws No. 170 of 2006 item 1217; Journal of Laws of 2007: No. 88 , item 587; No. 99, item 665; No. 127, item 880; No. 191, item 1373; No. 247, item 1844);
- ORDINANCE OF THE MINISTER OF INFRASTRUCTURE of 12 April 2002 concerning required technical conditions for buildings and their locations (Journal of Laws No. 75, item 690, further amended) consolidated text at: www.snb.org.pl;
- PROCLAMATION OF THE MINISTER OF ECONOMY, LABOR AND SOCIAL POLICY of 28.08.2003 concerning the announcement of consolidated text of the Ordinance of the Minister of Labor and Social Policy regarding general occupational health and safety rules, attachment: the Ordinance of the Minister of Labor and Social Policy of 26.09.1997 (consolidated text, Journal of Laws No. 169, item 1650 of 2003);
- ORDINANCE OF THE MINISTER OF INTERNAL AFFAIRS AND ADMINISTRATION of 7 June 2010 r. fire safety of buildings and other building structures and land (Journal of Laws No. 109, item 719);
- ORDINANCE OF THE MINISTER OF INFRASTRUCTURE of 2 September 2004 concerning an accurate range and form of design documentation, technical specification of construction and commissioning, as well as functional-utility program (Journal of Laws No. 202, item 2072);
- ORDINANCE OF THE MINISTER OF INFRASTRUCTURE of 23 June 2003 concerning information on safety and health protection, as well as safety and health protection program (Journal of Laws No. 120, item 1126);
- ORDINANCE OF THE MINISTER OF LABOUR AND SOCIAL POLICY of 26 September 1997 general regulations on occupational health and safety (Consolidated text: Journal of Laws No. 169 of 2003, item 1650) (Amendments: Journal of Laws No. 49 of 2007, item 330);

Electrical System

Polish standards and standards that are translations of European standards issued by CENELEC and international standards issued by ISO, which are the basis for design and installation works:

1. Set of standards concerning electrical systems in buildings -
   - PN-IEC 60364 Electrical Systems in Buildings

2. Standard concerning interior electrical lighting -
   - PN-EN 12464-1:2004 Light and Lighting – Workplace Lighting - Part 1: Interior Workplaces

3. Standards concerning lightning protection of buildings
   - PN-IEC 61024-1:2001 Lightning Protection of Buildings-General Rules - PN-IEC 61024-1-1:2001 Lightning Protection of Buildings – General Rules – Choosing the Level of Protection for Lightning Protection Devices
   - PN-EN 50310 Using Bonding and Earthing Connections in Buildings with Computer Equipment Installed

4. UPS Standards:

Safety standards:

- PN-EN 62040-1-1:2006 Uninterrupted Power Supply Systems (UPS)-Part 1-1: General Requirements and Requirements Regarding the Safety of UPS Devices Used in Places Accessible for Operators,
- PN-EN 62040-1-2:2005 Uninterrupted Power Supply Systems (UPS)-Part 1-2: General Requirements and Requirements Regarding the Safety of UPS Devices Used in Places with Limited Access

Standards for Electromagnetic Emission and Disturbance Resistance

- PN-EN 62040-2:2006 Uninterrupted Power Supply Systems (UPS)-Part 2: Requirements Regarding Electromagnetic Compatibility (EMC)

Certificates used:

- ISO 9001:2000 Quality management systems - Requirements (Polish counterpart-PN-EN ISO 9001:2001)
- ISO 14001:2004 Environmental management systems - Requirements with guidance for use (Polish counterpart - PN-EN ISO 14001:2005).

5. Standards for electric generators:

- PN-ISO 8528-1:1996 Alternating Current Generators Powered by Internal Combustion Engines-Application, Classification and Maintenance Requirements,
- PN-ISO 8528-6:1997 Alternating Current Generators Powered by Internal Combustion Engines-Test Methodology,
- PN-EN 60034-1:2005 (U) Electric Rotating Machines-Part 1: Electrical Rating and Parameters,
- PN-EN 60034-2:2000 Electric Rotating Machines-Methods of Specifying Loss and Capabilities through Tests (Excluding the Machines of Railway Vehicles),
- PN-EN 60034-8:2005 Electric Rotating Machines-Part 8: Designation of Outputs and Rotation Direction of Rotating Machines,
- PN-EN 60034-14:2004 (U) Electric Rotating Machines-Part 14: Mechanical Vibrations of Specified Machines with Shaft Heights of 56 mm and more-Measurements, Evaluation and Boundary Values of Vibration Intensity,
- PN-EN 60034-22:2000 Electric Rotating Machines -Alternating Current Generator for Electricity-Generating Units Powered by Internal Combustion Engines,
- PN-93/T-06450 Radio-frequency Interference-Devices and Methods for Radio-frequency Interference Measurement,
- PN-E-06704:1994 Electric Rotating Machines-Methods for Determining Synchronous Machine Quantities through Tests ,
- PN-87/B-02156 Building Acoustics-Methods for the A Sound Level Measurement,
- PN-87/B-02151.02 Building Acoustics-Noise Protection in Buildings-Acceptable Internal Noise Level.

6. Standards concerning specification of reliability requirements and reliability analysis:

- PN-EN 60300-3-1:2005 Reliability Management-Part 3-1: Applications Guide-Reliability Analysis Techniques-Methodology Guide,
- PN-EN 61078:2006 (U) Reliability Analysis Techniques-Reliability Block Diagram and Boolean Methods,
- PN-IEC 60300-3-4:2001 Reliability Management-Applications Guide-Guide for Specifying the Reliability Requirements

5.1. Standards

Telecommunications and computer systems compliant with standards

- PN-EN 60825-2:2005 (U) Safety Of Laser Products - Part 2: Safety Of Optical Fiber Communication Systems.
- PN-EN 60950-1:2004 Information Technology Equipment-Safety-Part 1: Basic Requirements,
- PN-EN 60950-21:2005 Information Technology Equipment-Safety-Part 21: Remote Power Feeding,
- PN-EN 41003:2001 Particular Safety Requirements For Equipment To Be Connected To Telecommunication Networks.

Standards dedicated for Data Centers

- PN- EN 50173-1:2011P Information Technology-Structured Cabling Systems-Part 1: General Requirements,
- PN-EN 50173-5:2009P, PN-EN 50173-5:2009/A1:2011E and PN-EN 50173-5:2009/A2:2013-07E Information Technology. Generic Cabling Systems. Part 5: Data Centers.
- PN-EN 50600-1:2013-06E Information Technology – Cabling System – Equipment and Infrastructure of Data Centers Part 1: General Concepts
- PN-EN 50600-2-1:2014-06 Information Technology – Cabling System – Equipment and Infrastructure of Data Centers. Part 2-1: Building Structure
- PN-EN 50600-2-2:2014-06 Information Technology – Cabling System – Equipment and Infrastructure of Data Centers. Part 2-2: Power Distribution
- PN-EN 50174-2:2010; A1:2011 Information Technology – Cabling System. Part 2: Planning and Performing Indoor Installation.
- ANSI/CSA/EIA/TIA TIA-942 (PN PN-3-0092) Datacenter Infrastructure Standards
- PN-EN 1047-2 Secure Storage Units - Classification And Methods Of Test For Resistance To Fire - Part 2: Data Rooms And Data Containers.
- PN-ISO/IEC 27001:2007 Information Technology-Security Techniques-Data Security Management System-Requirements. ISO/IEC 27002:2005 Information Technology-Practical Rules for Data Security Managements
- TIA-942: Data Centre Cabling captures IT, power, resilience, HVAC, security published in 2005
- ISO/IEC 24764: Data Centre Cabling based on CENELEC EN 50173-5 approval anticipated 2010

Fire Safety Standards

Standards applicable during fire safety issues examination.

- PN-EN 1047-1:2006 Secure Storage Units-Classification and Fire Resistance Test Methodology-Part 1: Data Racks and Floppy-disk Cartridges,
- PN-EN 1047-2:2002 Secure Storage Units-Classification and Fire Resistance Test Methodology-Part 2: Data Rooms And Data Containers,
- PN-EN 1363-1:2001 Fire Resistance Tests-Part 1: General Requirements,
- PN-EN 1363-2:2001 Fire Resistance Tests-Part 2: Alternative and Additional Procedure,
- PN-EN 54-2:2002/A1:2007 (U) Fire Alarm Systems-Part 2: Fire Alarm Centers,
- PN-EN 54-3:2003/A2:2006 (U) Fire Alarm Systems-Part 3: Fire Alarm Devices-Sound Alarms,
- PN-EN 54-4:2001/A2:2006 (U) Fire Alarm Systems-Part 4: Power Supply Units,
- PN-EN 54-5:2003 Fire Alarm Systems-Part 5: Heat Detectors-Point Detectors,
- PN-EN 54-7:2004/A2:2006 (U) Fire Alarm Systems-Part 7: Smoke Detector-Point Detectors Using Scattered Light, Transmitted Light or Ionization
- PN-EN 54-11:2004 / A1:2006 Fire Alarm Systems-Part 11: Manual Fire Alarms,
- PN-EN 54-20:2006 (U) Fire Alarm Systems-Part 20: Aspirating Smoke Detectors,
- PN-EN 54-21:2006 (U) Fire Alarm Systems-Part 21: Devices for Transmitting Alarm and Damage Signals,
- ISO 14520 -1, -5, -14 Gas Fire-suppression Systems-Design and Physical Properties.

Standards concerning intrusion protection and electronic protection systems

List of basic standards applicable during the examination of the issues of intrusion protection and electronic protection systems.

- PN-EN 1143-1:2006 Secure Storage Units-Requirements, Classification and Intrusion Resistance Tests Methodology-Part 1: Cabinets, ATM Cabinets, Rooms and Room Doors,
- PN-EN 1300:2006 Rooms and Equipment for Value Storage-Classification of High Security Locks According To Their Resistance To Unauthorized Opening ,
- PN-E-08390-14:1993 Alarm Systems-General Requirements-Rules of Use,
- PN-93/E-08390 Set of Standards: „Alarm Systems-Intrusion Alarm Systems",
- PN-EN 50131 Set of Standards „Alarm Systems-Intrusion and Assault Alarm Systems",
- PN-EN 50136 Set of Standards „Alarm Systems-Systems and Devices for Alarm Transmission",
- PN-EN 50133 Set of Standards „Alarm Systems-Access Control Systems",
- PN-EN 50132 Set of Standards „Alarm Systems-CCTV Surveillance Systems for Use in Security Applications",
- PN-EN 50130-4:2002/A2:2007 Alarm Systems-Part 4: Electromagnetic Compatibility-Standard for a Group of Products: Requirements Concerning the Resistance of Fire, Intrusion and Personal Alarm System Devices.

Other Standards

Standards concerning protection against flooding related to fire extinguishing, dust, gas or smoke:

- PN-EN 1634-3:2006/AC:2006 Fire Resistance Tests of Doors and Shutters-Part 3: Testing Smoke Protection of Doors and Shutters,
- PN-EN 60529:2003 Ingress Protection Ratings of Enclosures (IP Code).

Standards concerning protection electromagnetic interference.

- PN-EN 55024:2000, PN-EN 55024:2000/A1:2002 (U), PN-EN 55024:2000/A1:2004, PN-EN 55024:2000/A2:2004 Electromagnetic Compatibility (EMC)-Computer Equipment – Protection Rating – Measurement Methods and Acceptable Levels.
- PN-EN 61000-4-3:2002 - Electromagnetic Compatibility (EMC). Part 4-3: Measurement and Test Methods-Test for Radiofrequency Electromagnetic Field Resistance.
- PN-EN 61000-4-8:1998/A1:2003 - Electromagnetic Compatibility (EMC). Measurement and Test Methods-Test for Electromagnetic Field Resistance.

5.2. Data Center Design Guidelines

5.2.1. Building Infrastructure

Before commencing with the performance of the detailed design, it is necessary to conduct the following evaluations and stocktaking:
1. Examination of the floor load capacity of the server room in terms of locating such IT equipment as disk arrays and type libraries (expected load capacity 1200 kg/m^2);
2. Examination of the server room height including raised access floor.
3. Examination of the roof load capacity in terms of locating heat exchangers for air conditioning and ventilation,
4. Examination of the roof load capacity in terms of locating electric generators, if it is impossible to locate it in the building or its vicinity.
5. Examination of a current fire resistance of walls, ceilings and existing fire compartments
6. Stocktaking of server rooms,
7. Stocktaking of a power cable route from a distribution center,
8. Stocktaking of an air conditioning refrigerant route to heat exchanger, stocktaking of an equipment transport route (computer and other) to server rooms (possible to expand the entrance),
9. Verification of electrical connection in terms of increased demand for electric power (verification of the existing connection conditions)
10. Verification of an existing neighboring building infrastructure concerning noise emitted from cooling systems and electric generators.

5.2.2. Use Requirements

Order:

- determining the future User's needs;
- number of devices and cabinets with a proper reserve of development possibilities;
- electric and cooling power;
- choice of proper equipment for energy distribution, power supply and full air conditioning;
- arrangement of cabinets and elements in a Data Center;
- choice of proper solutions for routing power supply, cabling and other systems;
- choice of proper Data Center protection;
- earthing and equipotential bonding and surge protection

Designing a particular solutions, follow the following rules:

- Choose highly reliable elements;
- Use excessive solutions in particular systems;
- Scatter elements of particular systems;
- Ensure optimal use of space – at this as well as the future stage of Data Center installation;
- Fulfill the highest requirements in safety and resistance

5.2.3. Classes of Availability

	Class 1	Class 2	Class 3	Class 4
Infrastructure Availability	Low	Average	High	Very High
Power Distribution Circuit - see EN 50600-2-2	Single-phase (no redundancy)	Single-phase (devices redundancy)	Multi-phase (systems redundancy)	Multi-phase (failure-resistant during maintenance)
Environmental Parameters - see EN 50600-2-3	No Requirements	Single-phase (no redundancy)	Single-phase (devices redundancy)	Multi-phase (systems redundancy)-Maintenance During Operation
Telecommunications and Computer Cabling - see EN 50600-2-4	Single Point-to-point Connections	Single Infrastructure Connection	Multiple Infrastructure Connections	Multiple Connections Using Various Paths

Considered as a whole, logical conjunction applies, i.e. the class of a Data Center is the same as the class of its weakest element.
Depending on the intended class telecommunications and computer cabling, the circuit has to be designed and made in accordance with the above table, PN-EN 50173-5 standard and future EN 50600-2-4 standard.

5.2.4. TIER Levels

Tier Classification

Tier I – Basic site infrastructure (non-redundant).
Tier II – Redundant capacity components site infrastructure (redundant).
Tier III – Concurrently maintainable site infrastructure.
Tier IV – Fault tolerant site infrastructure-we consider a single event that has a significant influence on the functionality.
Uptime Institute–Organization created by owners and operators of Data Centers in 1993. Independent from manufacturers. Works and experiences gave rise to Tier classification. Initially, it was strongly connected with TIA-942 standard. Today, there is no reference to Tier classification in TIA-942.
Tier Standards: Topology and Operational Sustainability emphasize infrastructure reliability and minimization of human error risk (a cause of 73% of all breakdowns in DC).

List of main requirements according to UPTIME INSTITUTE Data Center Site Infrastructure Tier Standard: Topology

	Tier I	Tier II	Tier III	Tier IV
Active Capacity Components to Support the IT Lead (IT - N)	N	N+R	N+R	N after Any Failure
Distribution Paths	1	1	1 Active and 1 Alternative	2 Concurrently Active
Concurrently Maintainable	No	No	Yes	Yes
Fault Tolerance	No	No	No	Yes
Compartmentalization	No	No	No	Yes
Continuous Cooling	No	No	No	Yes

Main elements to focus on during the design process:

- Mechanical Systems-cooling in general,
- Electric Systems-safety and reliability of power supply
- Supportive Systems-fuel supply for generators, building automation system (server room), water supply, fire safety including EPO (Emergency Power Off).

Separate connection paths to external operators are required in Tier III and separate compartmentalization is required in Tier IV.

There is no special requirements when it comes to security systems – it depends on user requirements and safety policy.

Common myths and misunderstandings related to Tier classification:

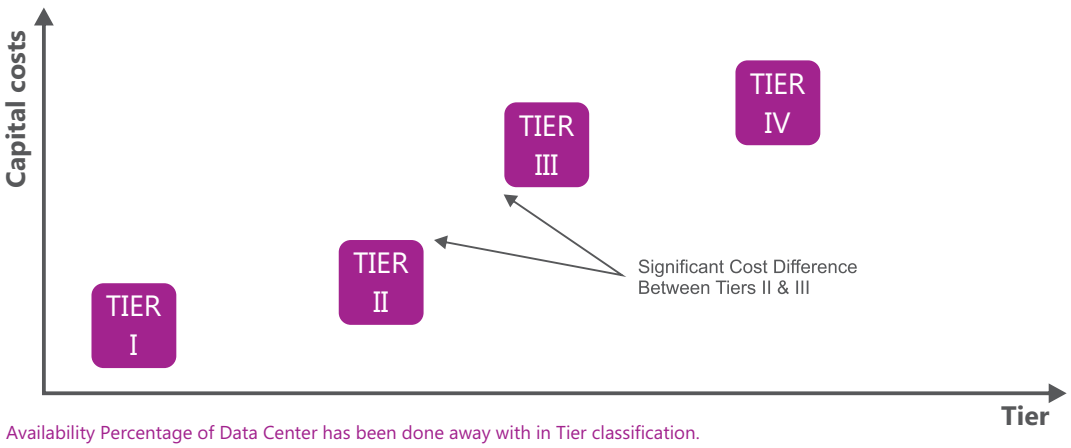
- N+1, N+2, N+N or 2(N+1) does not determine a Tier Level; for some systems it is possible to reach Tier IV in N+1;
- Location does not influence Tier Level;
- Choice of cooling method (underfloor or top) depends on a user and their capabilities and preferences;
- Tier standard does not require raised access floor or cool/warm corridor – it just may influence the efficiency of cooling

Special requirements of Tier III and IV in relation to generators: use only those which are designed for continuous operation and have Continuous Power Rating parameter.
Generators with Stand-by and Prime Power Rating are acceptable at Tier I and II.

Determining the Tier level depends on business expectations for Data Center:

- Will maintenance shutdown be possible? If YES – Tier I or II; if NO Tier III or IV;
- Will unplanned shutdowns be possible? If YES – Tier III; if NO Tier IV,

Diagram showing relative difference between costs and TIER levels:



Availability Percentage of Data Center has been done away with in Tier classification.

5.2.5. Power Usage Effectiveness

PUE stands for Power Usage Effectiveness. From the point of view of ecology, it is one of the most parameters of Data Center. It is calculated through dividing the total power of an object by the measured power of every IT equipment in the Data Center. This includes every computable, data storage and network devices, which also includes such additional equipment as monitors, working stations and other data center control devices. Total power is the sum of power of IT equipment and cooling systems, nodes and other receivers, such as lighting.

The authors of the standards wrote in the official declaration that PUE was created to help provide an efficient measurement of power effectiveness, which allows comparison of these values, analysis and working out new methods of reducing the power usage.

A question that surely many data center maintainers ask is: how to reduce this value? We provide a couple of possible solutions:

- Free cooling-cooling solution in which a data center is cooled with an external air-recommended in cooler climates. This method helps to reduce the usage of power for cooling to the minimum-no cooling devices or fans are used.
- Measuring PUE-regular check-ups of this indicator helps to see how it changes and to take steps toward its reduction.
- Increasing tolerable temperature-server rooms are rarely visited, so tolerable temperature may be increased (of course within safe values).
- Using better power saving equipment-it is not worth saving on equipment which on the long run turn out to be not efficient. It is better to spend more one a solution which will provide maximum power saving.

5.2.6. Uninterruptable Power Supply Systems

Power Supply Categories

Category	Power Supply Reliability Requirements	Type of Power Supply	Examples of Users
I	Basic. Breakdowns and outages may last relatively long, even a couple of minutes.	One power line from distribution grid. Backup power not required.	Single-family house. Low multi-family houses.
II	Higher. Power outage should be reduced to a couple of seconds.	Two independent power lines from distribution grid or one power line and electric generator.	High rise multi-family buildings.
III	High. Power outage should be reduced to ⩽1 sec.	Two independent power lines from distribution grid and an automatic backup power supply.	High rise multi-family buildings, big hotels, banks, hospitals, broadcasting companies, airports, buildings of central administration etc.
IV	Very high (uninterruptable power suply). Power outage of selected receivers are not allowed.	As above with an addition that one of the backup power supply devices, rotating or static, should provide uninterruptable supply of power to receivers.	Entire buildings or dedicated departments and set of equipment of very important use in category III buildings.

Power Supply-Requirements

Journal of Laws 1995.50.271 Ordinance of the Minister of Communications of 21 April 1995 r. concerning required technical condition of power supply for communications buildings.

In order to achieve high reliability of IT equipment, the following guidelines for electrical system parameters have to be followed:

There shall be a separate power supply network for computer equipment, TN-S network with protective conductor separated from neutral conductor. Earthing resistance lower than 5 Ohm.

Power supply circuits of IT equipment should be separated from other circuits, such as: ventilation, air conditioning, lighting etc.

Patch cord earthing units as well as metal elements of building structure, raised floor supports and pipe lines are to be connected to one earthing strip

Surge protections are required.
Frequency of the power supply network: 50Hz +/- 0,5Hz

Voltage drop on a power cord: not higher than 1.5% at maximum planned load.

Data Center infrastructure power supply should be based on two external independent power lines that can automatically switch. A correct design of such a power supply system should be prepared according to one of the TIER standards

Power Supply System Components:

Regardless of the type and size of a Data Center, we can divide the power supply system into several components:

1. External Power Supply - power transformer. Basic power supply source in data center. For higher security, two separate power transformers connected to separate power lines should be used.
2. Internal Power Supply - electrical generator. Basic power supply source for locations where receivers are not connected to electrical grid or where there is poor infrastructure. It is also a backup power supply for Data Centers switched on automatically upon the basic power outage.

Choosing electrical generator, remember about:

- Electrical generator's power after taking into account inrush current of the powered equipment
- Fuel capacity and fuel consumption – the values on which the time of independent operation of power supply depends
  - optimal location of the device, including the level of emitted noise and pollution, necessity of oxygen supply and protection against weather conditions and damages. Generators may be in indoor and outdoor versions. Additional functions, such as: fuelling during the operation of the machine, possibility of remote control of the machine, for example, through Simple Network Management Control (SNMP)

- Main Low-voltage Distribution Center Contact point of a building system with power supply sources. It should include proper security, circuit breaker, network analyzer and Automatic Transfer Switches
- Uninterruptable Power Supply-UPS. Backup power supply providing uninterrupted power supply of the highest quality. If there is a power outage, it always takes some time to restore the power supply by electrical generator. UPS fills this time, so that the power supply is uninterrupted.
- Power Distribution System
  - IT Distribution Center
- A point where voltage is distributed to particular blocks of equipment. This is where UPS devices are connected and local security and power meter per cabinet/section installed.
- Power Strip-power distribution within a cabinet-chapter 8

6. Server Cabinets

The choice of a proper server, network or telecommunications and computer cabinet is extremely important. It will influence cooling, fire extinguishing and even power supply systems, as well as functionality for the end user.

Besides physical damage protection it also provides:

- proper ventilation and cooling
- easy cabling organization
- possibility of routing and connecting proper power sources

At the initial stage of Data Center design, you have to plan the arrangement of cabinets taking into account rooms sizes and sizes of the cabinets. They are available in various sizes, in heights from 42U to 47U and depths of 1000 and 2000. Server cabinets with load capacity above 1200 kg are recommended.
BKT 4DC Cabinets are designed for demanding Data Centers, where functionality, easy installation and safety play a key role. They provide a proper temperature and moisture.
Easy installation thanks to the innovative system:
- toolless mounting of 19'' sections with possibility of dividing cabinets into two parts with different depths

- toolless setup of the base

6. Server Cabinets

- toolless side walls mounting

- toolless mounting of covers

- toolless door mounting/removing

The cabinets structure can sustain loads up to 1500 kg (if using casters it is 1000 kg), which is a significant parameter when cabinets are more and more tightly packed.

For cabinets safety, they include a four point lock, internal hinges and universal locking system with a possibility of using electromagnetic lock.

6. Server Cabinets

Pay attention to power distribution within a cabinet. It poses a problem especially in the case of cabinets 600 mm in width. BKT 4DC Cabinets can be equipped with vertical power distribution units outside the 19'' area, without interfering in mounting space

BKT 4DC Cabinets can be adjusted to meet individual needs through a wide range of additional accessories, such as: cable trays, concealing elements, grommets and cable holders.

7. Cooling Systems

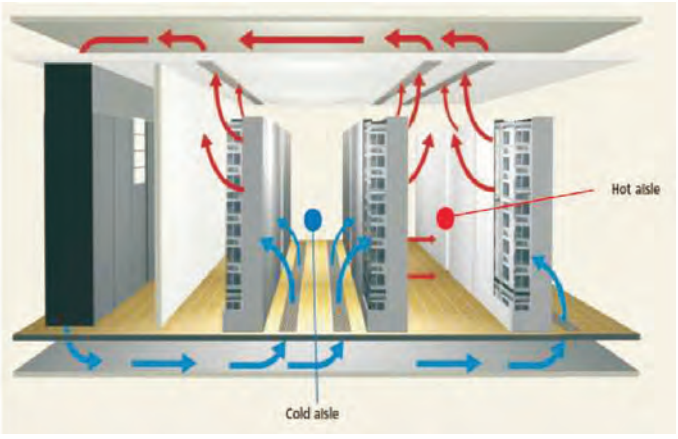
Today, consolidation and more dense packing of equipment makes it impossible to use traditional solutions when it comes to cabinets. Preventing heated air recirculation in servers protects from equipment overheating. Separation of cool air from heated air increases significantly cooling power. Properly selected cooling systems contributes to the longer lifetime of the electronic equipment. It also reduces the risk of a breakdown which are the cause of breaks in operation.
BKT Elektronik offers dedicated cooling systems for large data centers as well as for smaller local ones. A complete offer of cooling cabinets, heat exchangers and chillers. Consultancy in design and installation.

Depending on cabinet power we can use the following devices:

Type of Solution	Expected Power per Cabinet
Cooling Cabinets (airflow under the raised floor)	up to 6kW
Cooling Cabinets (airflow under the raised floor) with NAUTILUS Casing	up to 9kW
Aisle Exchangers for NAUTILUS Casing	up to 21kW
SideCooler Exchangers (water-air) for IP54 cabinets	up to 21kW

7.1 Close Control Air Conditioning Units (air flow under the raised floor) up to 6kW

Most popular solution in Data Centers where cool air is directed under the raised floor. Air moves through perforated floor panels to the area of cool corridor in front of the cabinets which takes the cool air in. Moving through the device, the air is heated and it escapes at the back of the cabinets. Heated air is sucked by the close control air conditioning units.
Note that close control air conditioning units are located outside the server rooms. It makes the access by maintenance service easier, because they do not have to enter the room with expensive equipment.
A disadvantage of this solution is limited cooling power and losses caused by mixing of heated and cool air.



7.2. Close Control Air Conditioning Units with Nautilus Casing (airflow under the raised floor) up to 9 kW

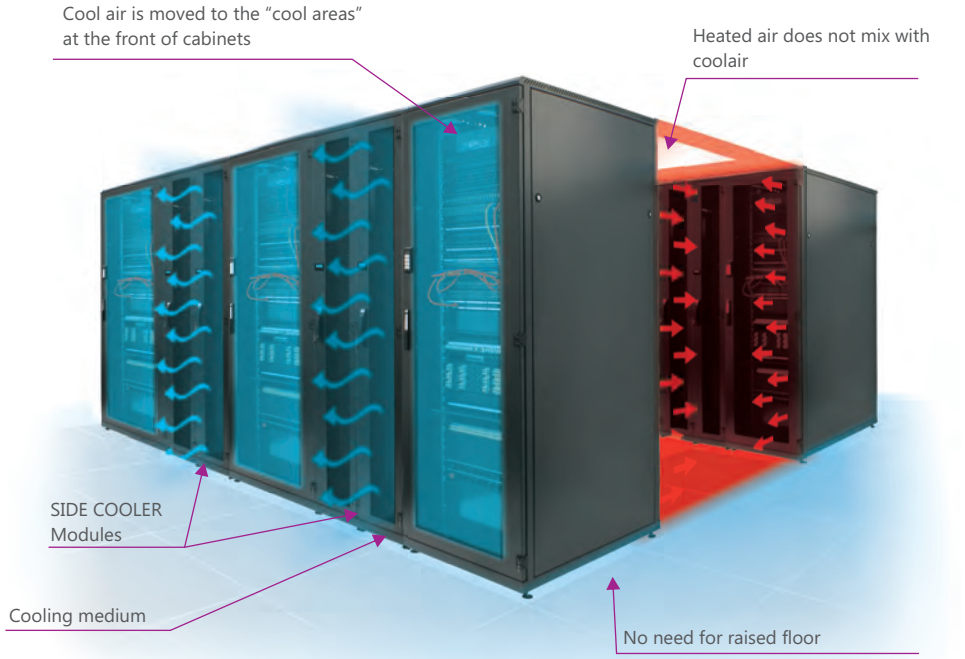
When there is a bigger need for cooling, the solution is to separate heated air from cool air. By using Nautilus casing, we close the heated/cool areas off. Additionally, it allows increasing the operation temperature of the system, which is very cost-effective in relation to power usage.

7.3. AISLE Heat Exchangers

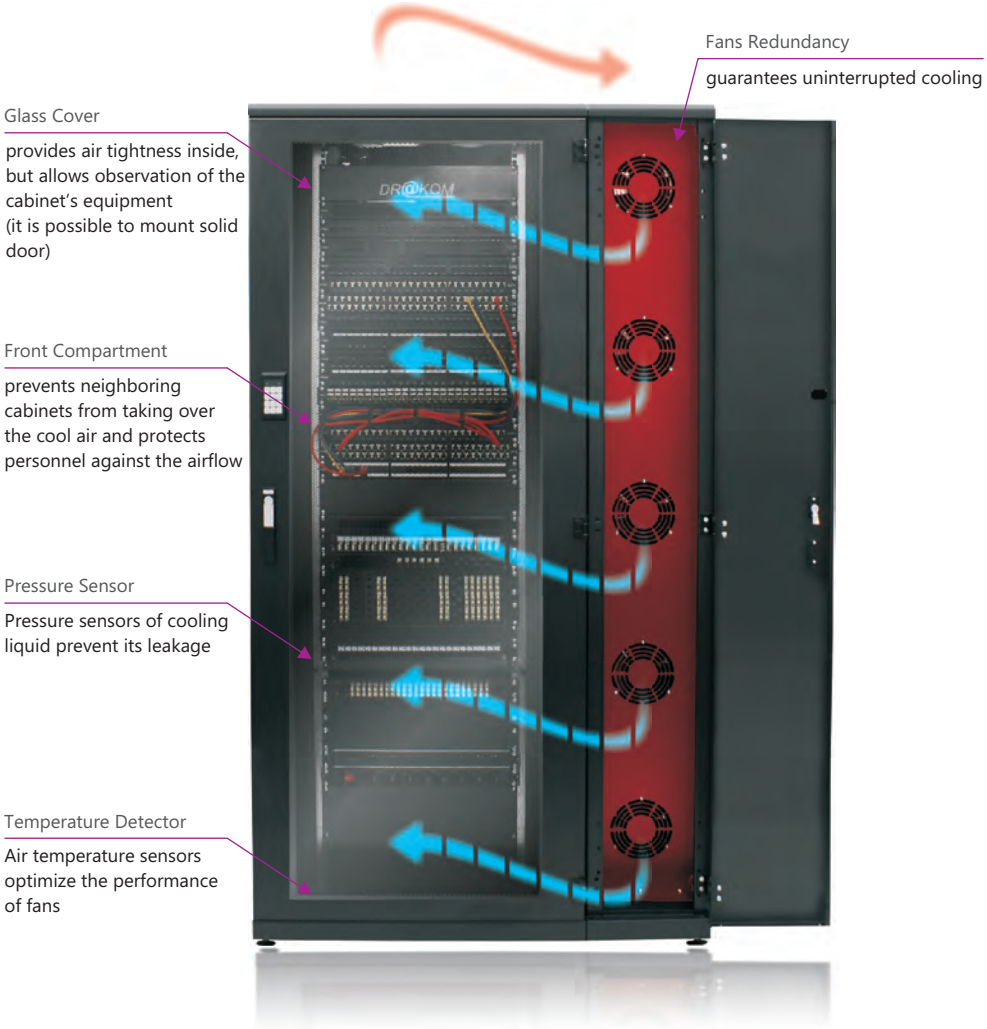
Designed for cabinet cooling in NAUTILUS row casing. This solution is dedicated for cabinets with increased power usage. Cooling units with 21kW power.

Solution advantages:

- Increased cooling efficiency
- Lower costs of power usage – fan power reduced to 50%
- Reduced CO2 emission
- Optimum cooling efficiency in existing Data Centers
- Redundancy-Reliability-Fast Maintenance
- Cabinet cooling at its entire height

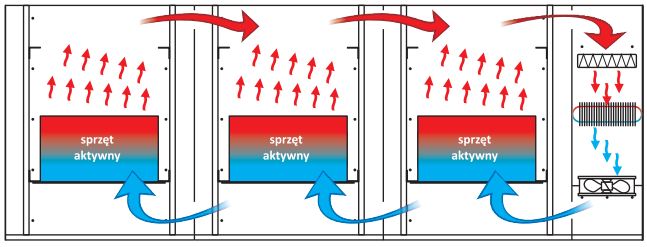


Rack module provides a cool air flow directly to the front of the IT equipment in cabinets. Airtight structure of the cabinet and the module prevents heated and cool air from mixing. This relatively small cooling unit is able to transfer up to 21kW of heat from each cabinet.

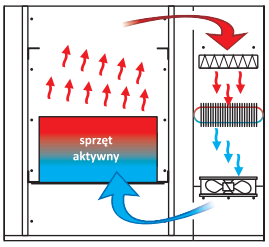


One rack cooling module may be used with several cabinets simultaneously, but the cooling efficiency per cabinet is relatively lower. Note that if redundancy is required, there has to be more modules used, because of airtightness of the cabinets.

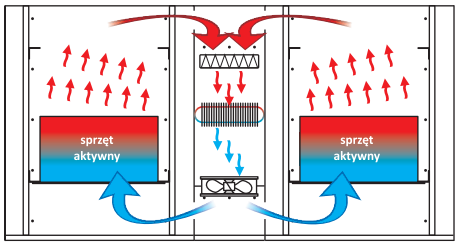
Configurations



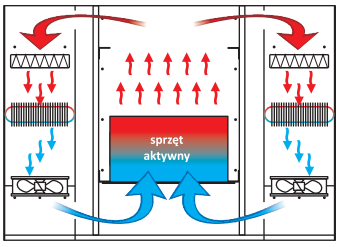
Efficiency up to 6 kW per 1 cabinet



Efficiency up to 20 kW



Efficiency up to 10 kW



Efficiency up to 40 kW

8. Power Distribution System

In data exchange systems the safety of electronic devices plays a very important role. This is where modern power distribution units come to the fore. They distribute the power and protect data storing, processing and transferring devices.

Modern distribution cabinets and server rooms differ significantly from solutions used just a couple of years ago. Modular equipment, cable organization systems, designators, stable connections, looks and safety are only few out of many features that distinguish the cabinets available on the market that are used in telecommunications and information technology, as well as in automation technology. The requirements for power distribution systems are definitely higher. They are expected to adjust to the source of a power supply. Number of receivers, load, security and additional elements are also taken into account. Choosing proper distribution unit, it is worth considering our products. We have a wide offer, which helps to choose a system precisely for a particular solution. The choice of a power distribution unit should be well thought out. Many factors are critical when it comes to the final effect, security and stability of the installed power supply system. Choose a proper input plug, power cord length, proper outlets, control and protection units.

Power Distribution System may be divided into two main branches:

1. Power Distribution Units
2. Maintainable systems of power supply and monitoring systems

8.1. Power Distribution Units

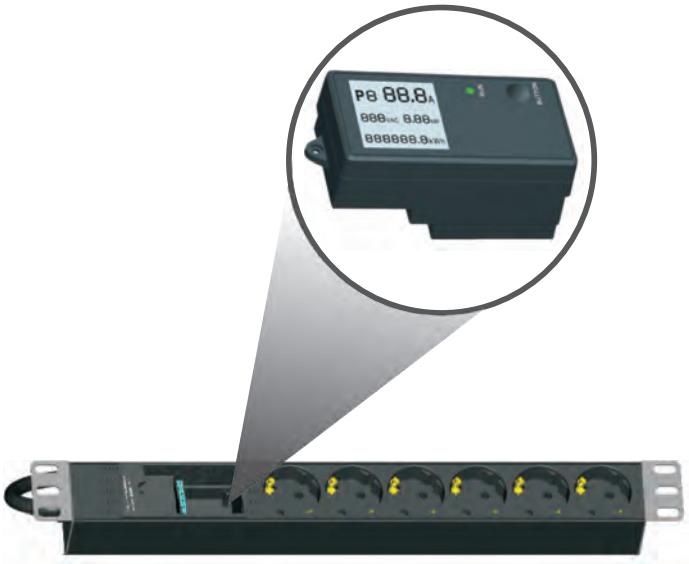
Power Distribution Units from our offer have a wide application in IT and telecommunications. They have been designed for use in small hanging cabinets, as well as in 19" standing distribution cabinets. Rich and diverse offer of input connectors, outlets, control and protection units to be used with 19" power distribution units will meet every need.
We expanded our offer concerning server rooms with three-phase power distribution units, whose modular and multifunctional structure allows us to sell ready-to-use products from our offer, as well as the assembly of one- or three-phase distribution units with current-carrying capacity of 32 A with a Customer to fulfill particular requirements of Investors. Building a power distribution unit from scratch, we can adopt the existing electric infrastructure, adjust the number and type of outlets for particular devices and add protection units and ammeters in a configuration in line with the current requirements of Data Center market.

a) 19" Power Distribution Units

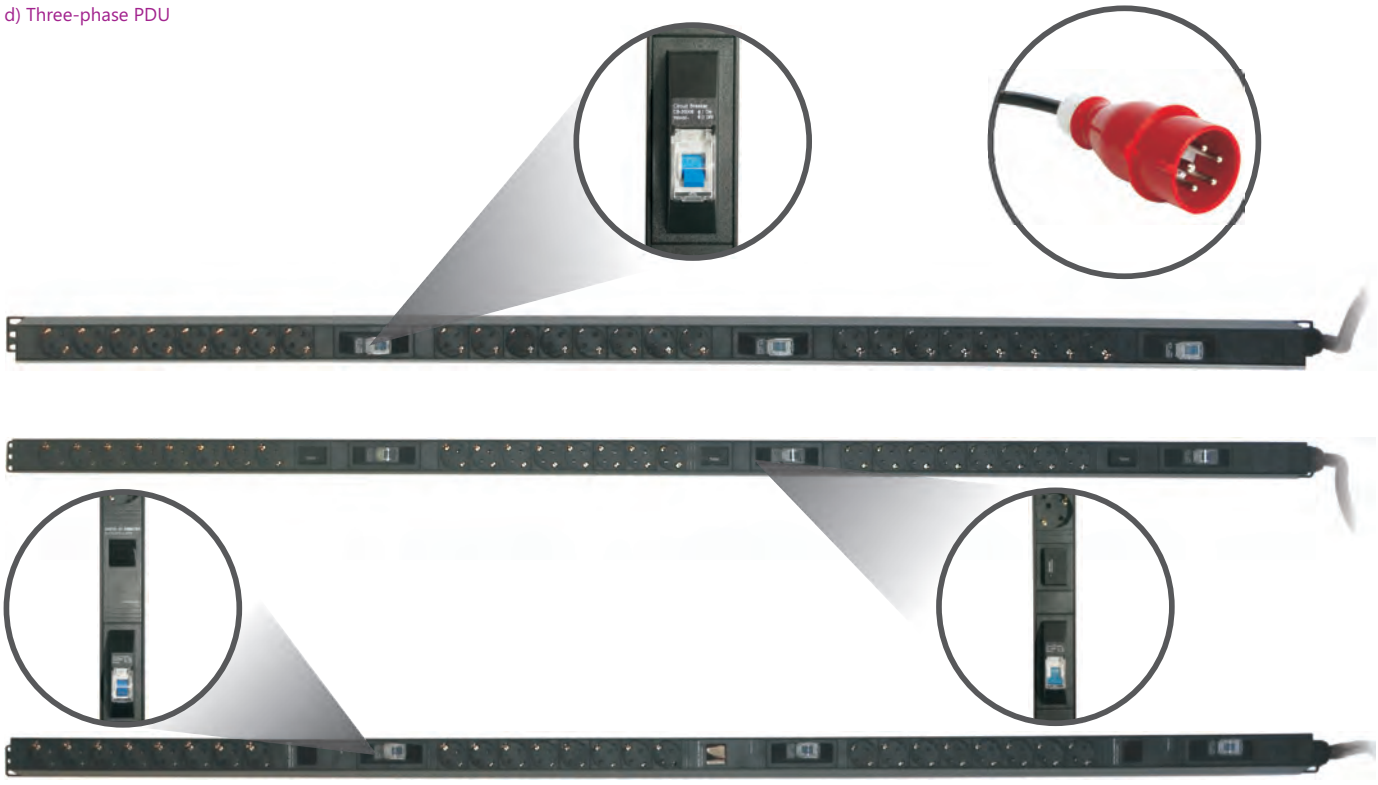
b) Vertical single-phase PDU

- ammeter with overload sound alarm

c) PDU with a power meter



d) Three-phase PDU



e) Designed PDU

For every special order of a designed PDU you can select such components as:

- Single- or three-phase power connectors IEC 60309 16A or 32A
  One or two power lines per PDU

8.1. Power Distribution Units

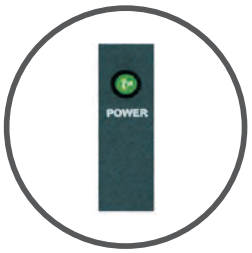

IEC320 C13


IEC320 C19


DIN49440

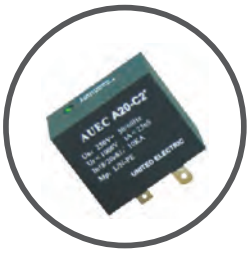

NF C61-314

- NF C61-314 outlets
- DIN49440 outlets
- IEC320 C13 outlets
- IEC320 C19 outlets



- LED indicators
- Fuses
- Automatic Fuses

- Overcurrent Circuit Breaker Residual
- current Circuit Breaker Residual
- current Circuit Breaker integrated with Overcurrent Circuit Breaker



- Surge Protective Device with a Filter

- Single-phase Ammeters with Overload Sound Alarm

- Three-phase Ammeters with Overload Sound Alarm

8.2.1. Network Power Manager-Maintainable Distribution Units

Network Power Manager

Development and unlimited access to network infrastructure has forced a natural development of power distribution units that now allow a remote power management and monitoring parameters of distribution cabinet conditions. Network Power Manager units allow the management of one- and three-phase power supply from 16 to 32 A. They increase the security, monitoring the conditions in server cabinet in case there are unwanted physical and chemical environmental factors, i.e. temperature, moisture, water, smoke. They also inform the maintainers through TCP/IP protocol about unauthorized access to the equipment inside a cabinet.

NPM Units

Features:

- Friendly, multi-user web interface
- Current total load
- Current total load of every outlet with adjustable alarming level
- State and change of state (on/off) of every outlet and saving the last state in case of device reset
- Sequential start-up programs of the entire PDU
- Programmable timer of every outlet
- Indications and status of connected detectors
- Operating system state
- Alarming system state and alarm values
- Adding, removing and modifying users

Monitoring of:

- Load of every outlet
- Total load of the unit
- Outlet state: on/off
- Temperature
- Moisture
- Presence of smoke
- Presence of water
- Door and cabinet side covers opening

Detectors:

- 3 temperature/moisture detectors
- 2 door opening detectors
- 1 smoke detector
- 1 water detector

Alarming about:

Minimum and maximum load of each outlet
Minimum and maximum temperature
Minimum and maximum moisture
Entire unit overload
Presence of smoke
Presence of water
Door and cabinet side covers opening

8.2.1. Network Power Manager-Maintainable Distribution Units

Ways of Alarming

- Internal alarm (inside buzzer)
- SNMP traps
- E-mail sent to administrators
- Event log

System Structure

- NPM units can be linked creating a chain of 10 devices managed from one IP address

Horizontal NPM Model

- Panel-mounting in 19" standard
- 1U height
- Input connectors: DIN49441 (16 A), IEC320 C20 (16 A) or IEC60309 (16 A/ 32 A)
- Output-8 front outlets; 4 back outlets
- Available outlets:

IEC320 C13

IEC320 C19

Supply Voltage: 230VAC
Maximum Current: 10 A per outlet, 16 A per unit

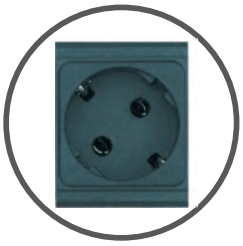
Vertical NPM Model

Vertical-mounting
Input connector IEC60309 (16 A/ 32 A)
Output-12, 16, 20 or 24 outlets

IEC320 C13

IEC320 C19

NF C61-314



DIN49440

Supply Power 230VAC
Maximum Current: 10/16 A per outlet, 16/32 A per unit

Vertical NPM units can be fitted with power meters

8.2.2. Environment Monitoring System (EMS)

Environment Monitoring System

It is an intelligent system of remote monitoring system of environment and power supply in one or several distribution cabinets. It is based on advanced technologies and provides effective, reliable and safe use. Thanks to it, a maintainer can easily monitor the environment and power supply in a cabinet through LAN or WAN.

Main Components of EMS

(MASTER)

(SLAVE)

(HUB)

(Metered PDU)

Master
It is a self-contained environment monitoring system of devices operated through network.

Slave
It is a passive element powered and controlled by the Master. Type and number of monitored devices is the same as in the Master. Slave is not self-contained and cannot run on its own.

HUB
It is a passive element that allow switching the type of connection between devices (EMS and NPM) from daisy-chain to star connection. Maximum number of controlled devices is 12. It is limited by system restrictions of devices (in the case of EMS it is 11). Hub eliminates the risk of losing the connection in the case of the failure of any daisy-chain connection link.

Metered Power Distribution Units
Monitored measuring MPD units with RS485 port are the part of EMS and use the following two types of modules:
SAVM showing current and voltage of the PDU on a LED screen and sending these parameters through RJ45 port (RS485).
SAVPEM additionally showing the current power usage and power meter on an LCD screen and sending these parameters through RJ45 port (RS485).

Monitored parameters:

- Power supply voltage
- Load
- Power meters on PDU
- Temperature
- Moisture
- Door opening detectors status
- Presence of smoke
- Presence of water

Detectors and distribution units

- 2 temperature/moisture detectors
- 2 door opening detectors
- 1 smoke detector
- 1 water detector
- 4 MPD units

8.2.3. Automatic Transfer Switch (ATS)

Automatic Transfer Switch

ATS is a device that provides redundant power supply for connected equipment. When there is a power cut at input A, ATS immediately and automatically switches to input B. Monitoring voltage and current, ATS helps to maintain continuous operation of connected devices.

Intelligent ATS

Maximum response time: ⩽16 ms
Monitoring:
Total current load
Voltages at input and outputs
Device system state

Remote Control:

Switching between inputs
Setting up alarm threshold

Alarms:

Exceeded the current load threshold set up by a user
Exceeded maximum current load of a device
Power supply failure at one of the inputs

Way of Alarming:

Sound and visual, e-mail

Log:

Saves every event for further analysis
Users management: setting up access permissions

Access:

Web (http)
SNPM (V1/V2/V3)
RS-232 port

Other Functions:

Clock setup
Device buttons lock
Time of switching back from backup
power supply to the main power supply

9. Integration and Visualization System

In order to complement the entire power distribution system, our company implemented to its offer Integration and Visualization System of maintainable components. Below is a brief description of SM4DC system, which includes:

- Integrating the maintainable NPM units
- Visualization of environmental information in distribution points
- Controlling and monitoring particular devices of IT infrastructure
- Monitoring particular power distribution centers
- Controlling and monitoring supply/exhaust ventilation centers
- Controlling and monitoring exhaust fans
- Controlling and monitoring fan coil units
- Monitoring security systems of an object
- Lighting control
- Possibility of integration with other low-voltage systems and Building Management System

Description of SM4DC Monitoring and Management System

SM4DC allows monitoring and visualization of IT infrastructure (maintainable NPM units). SM4DC system can be developed in terms of its size, as well as functionality with no need to replace software or a server. The fundamental principle in monitoring and visualization system design is using an open system that is based on the latest technological solutions and allows connecting to a server all the devices with external communication modules. This is to provide the visualization of a building's system, reports on operating parameters of particular system, as well as alarms about the state of devices and exceeded permissible operating parameters. The main element of an SM4DC system is a server (controller) with specialist software that allows monitoring particular devices with external communication system drivers. Controlling stations may be random PCs with an internet browser supporting Flash. SM4DC software is divided into two independent parts in order to separate configuration functions from monitoring and controlling functions:

a) Administrative part

- Entering schematic designs of objects
- Inserting visualization and control elements of various types
- Configuration of operating parameters of particular systems
- Assigning users existing in a system (assigning to groups)
- Giving advanced permissions to particular users/groups

b) User part

- Logging in to a system
- Visualization an control of system components, depending on permissions
- Monitoring system state

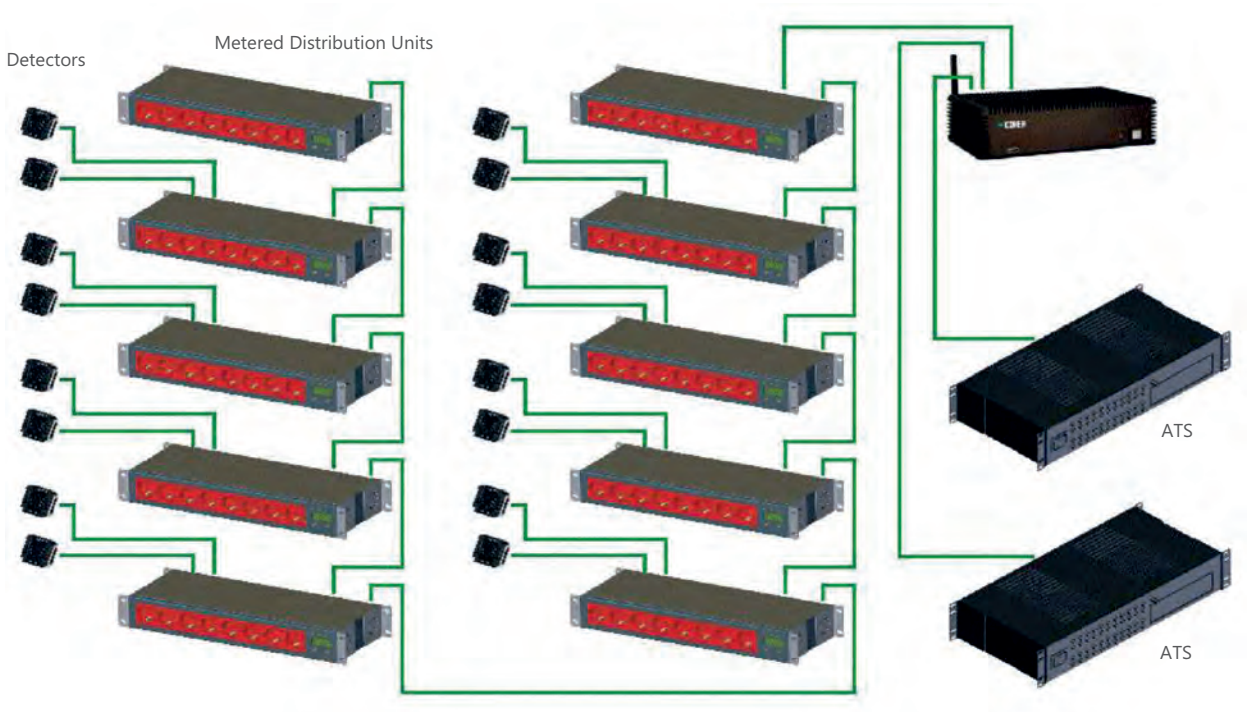
Basic functions of SM4DC software:

Visualization and remote control of system devices using dynamic and interconnected graphics. Interconnections allow switching between views of a particular system, device or other system object. System signals are concurrently modified with colored graphics that change color of a symbol or make it pulsate, update a displayed value, display a text message or a symbol.
Support of alarms reported by drivers and system, including alarm messages are displayed in Polish and English. The messages are displayed according to alarm priorities (the first is fire alarm, second is security alarm, and so on) and chronologically (the first are the earliest messages). Additionally, the system provides buffering of all alarms reported simultaneously. It allows saving current data from monitored systems and devices for their further use in creating reports, which can be exported to MS Excel.
System of permissions and security protects against unauthorized access. Every operator has their own ID and password. System administrator can give a proper range of permissions to each operator, which helps to effectively organize the cooperation between system administrator, operators and other users.

Main components of SM4DC system

The basic component of SM4DC system is SM4DC SMS VISUALIZATION AND DATA RECORDING CONTROLLER with a license (1 user, 15 screens and 150 components) and 2U rack server. System launching-configuration of basic connections: SM4DC-distribution unit and NPM-detectors.

SM4DC System Diagram



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